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Effect of Abomasally Infused Methionine, Bypassed Methionine, and Hydrolyzed Feather Meal in Steers

P. R. Leme, F. N. Owens and K. S. Lusby

Story in Brief

Five mature Hereford steers fitted with rumen and abomasal cannulas were fed prairie hay *ad libitum* and 2.2 lb of 20 percent crude protein supplements with 65 percent of the protein from hydrolyzed feather meal (HFM) or the equivalent from coated slow release urea (SRU) with different levels of oleyl-methionine. Oleyl-methionine levels were 0, 30, 60, and 90 grams (g) per day. The levels 30 and 60 g were continuously infused in the abomasum and the 90 g level was fed orally.

Similar values for the treatments were observed with respect to daily dry matter intake, cellulose digestibility, nitrogen retained (g/day or as a percentage of the intake) or nitrogen digestibility. Digestibility of dry matter was greater ($P<.05$) for rations containing HFM or SRU plus oleyl-methionine than SRU alone. Nitrogen reaching the abomasum was higher than intake for all treatments reflecting nitrogen recycling or poor recovery of the marker used.

Hydrolyzed feather meal produced less ammonia and microbial nitrogen in the abomasal digesta than the SRU supplements. No consistent effects of oleyl-methionine in microbial synthesis and bypass nitrogen were observed. Results suggest that methionine is not the first limiting amino acid for cattle fed poor quality forage.

Introduction

Several studies have indicated that certain nutrients may be limiting to cattle fed low quality roughages. Nitrogen certainly is the more deficient nutrient in these conditions and is generally supplied as plant protein or NPN.

Under some situations, however, the protein nitrogen supplemented could be used more advantageously to the animal if digested abomasally instead of going through the process of rumen fermentation. This is especially true for high quality protein which may be degraded and resynthesized to microbial protein of inferior quality in the rumen. The mircrobial protein has been shown in some studies to have low levels of certain amino acids, especially methionine and depending on the physiological function of the animal, methionine may be limiting to maximum performance.

Hydrolyzed feather meal, a byproduct of the poultry industry, contains approximately 80 to 90 percent crude protein and could possibly be used to increase bypass of protein since this product has a lower solubility than most of the plant proteins commonly used in cattle feeds. Also, its high content of the sulfur amino acid cystine could possibly spare part of the requirement of methionine.

The purpose of this experiment was to compare the effect on the nitrogen utilization by steers fed low quality roughage and urea of methionine treated to bypass rumen fermentation, methionine fed orally, methionine infused abomasally and hydrolyzed feather meal.

Materials and Methods

Five mature Hereford steers fitted with permanent rumen and abomasal cannulas were used. Treatments (Table 1) consisted of 20 percent crude protein supplements in which 65 percent of the protein was from hydrolyzed feather meal (HFM) or the equivalent from coated slow release urea[1] (SRU) with different levels of methionine treated with a mixture of glyceryl tristearate and oleic acid (oleyl-methionine).[2] The levels of oleyl-methionine added were 0, 30, 60 and 90 g per day to the urea based supplements. The 30 and 60 g levels of oleyl-methionine were infused continuously in the abomasum while the 90 g level was fed orally. The steers received 2.2 lb of supplement daily in one meal in addition to prairie hay fed *ad libitum*.

The experimental design was a 5 x 5 Latin square with each period consisting of an eight-day adjustment and a six-day collection period. Feces were collected daily from day 1 to 5 of each collection period, weighed and a 10 percent aliquot taken. The aliquots were composited for each period and then sampled for laboratory analyses. Urine was also weighed daily and a 5 percent aliquot kept and composited for analysis. Rumen and abomasal samples were taken on day 5 at 0, 4 and 8 hr relative to the a.m. feeding of the supplement and at 2, 6 and 10 hr after feeding on day 6.

Equal aliquots from abomasal samples were combined to provide a single animal composite for analysis. The composite was separated in solid and liquid phases by centrifuging at 10,000 g for 30 minutes. The solid sample was dried and ground; the liquid frozen and stored. Cellulose digestibility was estimated by placing cotton strips of known weight into the rumen for 48 hr on days 2 and 3 and weighing again after washing and drying.

Chromium sesquioxide (Cr_20_3) and polyethylene glycol (PEG) were used as indicators to estimate the amount of solid and liquid digesta reaching the abomasum daily. Chromium sesquioxide was fed twice daily (7.5 g mixed with 200 g of ground corn) and PEG was infused in the rumen twice daily dissolved in water (37.5 g of PEG in 100 ml of water).

[1]Product of NIPAK Corp., Pryor, Oklahoma.
[2]Product of Degussa Chemicals Inc., Frankfurt, Germany.

Table 1. Composition and crude protein content of the rations.

Item	IRN[a]	Ration (% DM basis) HFM	SRU[b]
Ingredient, %			
Slow release urea		---	6.5
Feather meal, hydrolyzed	5-03-795	17.6	---
Corn, grnd.	4-02-992	53.6	45.6
Alfalfa, dehy. grnd.	1-00-525	10.0	10.0
Cotton seed hulls	1-01-599	11.8	30.4
Dicalcium phosphate	6-01-080	3.0	3.5
Potassium chloride	6-03-656	2.0	2.0
Trace mineral mix		2.0	2.0
Crude protein, total %		20.8	20.9

[a]International Reference Number. Atlas of Nutritional Data on United States and Canadian Feeds. 1971. National Academy of Sciences, Washington, DC.
[b]This ration was supplemented with 0, 30, 60 g (both infused abomasally) and 90 g (fed orally) of oleyl-methionine. Treatments were named SRU, SRU30, SRU60, SRU90, respectively.

Abomasal solid and liquid samples were also analyzed for ribonucleic acid (RNA). Microbial nitrogen was estimated from abomasal RNA assuming a nitrogen content of 13.2 percent in the RNA and that 10 percent of the microbial nitrogen was RNA nitrogen. Protein-nitrogen bypassing rumen degradation was estimated as non-ammonia nitrogen minus microbial nitrogen. Microbial protein was calculated as microbial nitrogen times 5.12 to correct for the nucleic acid content, which has limited value for the host animal (Kropp *et al.*, 1977a).

Results and Discussion

Dry matter intake was similar for the treatments (Table 2), however, a highly significant effect of animals and periods was observed for these parameters as well as for almost all other parameters studied. The SRU30 treatment resulted in greater dry matter intake and this probably affected the other parameters since an increase in dry matter intake is generally followed by an increase in the rate of passage of the diet and a decrease in total dry matter digestibility. As a result, greater abomasal solid and liquid digesta and lower ruminal and total dry matter digestibility were observed for this SRU30 treatment. Total solid and liquid digesta reaching the abomasum per day were similar for the treatments. Ruminal dry matter digestibility was lower ($P<.05$) for the SRU treatment. Cellulose digestibility estimated with cotton strips placed in the rumen was also similar for all treatments.

Total nitrogen intake (Table 3) was similar for the treatments except for the SRU30 treatment that had a higher nitrogen intake resulting from the greater dry matter intake as explained earlier. Also as a result from the greater dry matter intake for the SRU30 treatment was an increase ($P<.05$) in fecal dry matter for this treatment. Similar urinary nitrogen values were observed for the treatments. Apparently the methionine infused or fed was in excess of the animals' requirements of this amino acid and failed to show any response in nitrogen utilization. Nitrogen digestibility was also similar for all treatments.

Total nitrogen reaching the abomasum (nitorgen in the dry matter plus in the liquid) was in all treatments higher than total nitrogen intake (Table 4). This may reflect, to some extent, nitrogen recycling to the rumen, which can be in considerable

Table 2. Matter digestion, total solid and liquid digesta reaching the abomasum and cellulose digestibility.

	Treatment					
Item	HFM	SRU	SRU30	SRU60	SRU90	SE[a]
Dry matter intake (g/day)	9173	9181	9723	9028	9096	260.8
Abomasal solid digesta (g/day)	5170	5053	5737	5080	5120	230.0
Abomasal liquid digesta (1/day)	125.8	129.9	142.1	129.1	123.4	4.4
DM digested in the rumen (%)	44.3	45.8	40.3	43.7	43.6	2.2
Total DM digestibility (%)	60.3[c]	56.9[b]	57.8[bc]	59.8[c]	60.1[c]	.7
Cellulose digestibility (%)	15.3	19.6	19.7	17.9	19.0	.8

[a]Standard error.
[bc]Means in the same line with different superscripts are significantly different ($P<.05$).

Table 3. Nitrogen digestion and retention.

	Treatment					
	HFM	SRU	SRU30	SRU60	SRU90	SE[a]
N intake (g)	107.3	109.4	114.7	109.7	108.9	4.2
Fecal N (g)	50.7[b]	52.7[b]	57.5[c]	50.2[b]	50.9[b]	1.1
Urinary N (g)	17.9	18.9	19.0	17.5	18.0	0.2
N retained (g)	38.7	37.8	38.1	42.2	40.0	3.1
N retained, % of intake	35.6	34.0	33.3	38.1	36.5	1.5
N digested (%)	52.6	51.7	49.9	54.3	53.4	1.0

[a]Standard error.
[bc]Means in the same line with different superscripts are significantly different (P<.05).

Table 4. Nitrogen fractionation of abomasal digesta.

	Treatment					
Item	HFM	SRU	SRU30	SRU60	SRU90	SE[a]
N intake (g)	107.3	109.4	114.7	109.7	108.9	
Abomasal N (g)	146.4[b]	142.9[b]	163.2[c]	148.2[b]	143.6[b]	6.1
N influx (g)	39.1	33.5	48.5	38.5	34.8	3.3
N influx, % above intake	35.0	30.3	42.1	34.8	32.8	2.9
Ammonia N (g)	1.7[b]	5.1[d]	6.1[d]	5.3[d]	3.0[c]	0.2
Non-ammonia N (g)	144.8[b]	137.8[b]	157.2[c]	142.9[b]	140.7[b]	6.1
Microbial N (g)	70.3[b]	82.6[c]	95.2[d]	83.4[cd]	80.8[bc]	3.4
Microbial N, % of abomasal N	47.9	57.2	59.0	56.5	56.3	1.5
Bypass N (g)	74.4[c]	55.2[b]	61.9[bc]	59.5[b]	59.9[b]	3.9
Bypass N, % of abomasal N	50.9[c]	39.1[b]	37.2[b]	39.9[b]	41.7[b]	1.4
Microbial N/100 g DM digested (g)	9.7	10.3	13.5	11.4	10.5	0.5

[a]Standard error.
[bcde]Means in the same line with different superscripts are significantly different (P<.05).

Table 5. Ruminal ammonia nitrogen.

Time after	Supplements					
feeding	HFM	SRU	SRU30	SRU60	SRU90	SE[a]
Hr	0.3	2.1	1.8	1.6	0.9	0.4
2	0.6[b]	2.6[c]	2.4[c]	2.1[bc]	3.8[c]	0.4
4	0.8	2.9	1.0	1.9	1.9	0.4
6	0.7	1.6	1.5	1.5	1.0	0.2
8	0.8	1.6	1.1	0.9	1.2	0.2
10	0.7	0.7	0.5	0.9	1.2	0.1

[a]Standard error.
[bc]Means in a line with different superscripts are significantly different (P<.05).

amounts with low protein diets. The rumen ammonia nitrogen levels for the different times after feeding (Table 5) were not significantly different in most cases due to the high variability caused apparently by the ingestion of feed and water.

In general, very low rumen ammonia levels were observed indicating that conditions were favorable to nitrogen recycling to the rumen. However, the large amount of nitrogen influx into the rumen in this experiment may also result of incomplete recovery of the markers utilized. This is possibly true with PEG because the recovery was affected by cottonseed hulls present in the ration.

Although a correction factor was estimated by incubating a PEG solution with different amounts of cottonseed hulls for different times, the overestimation of the amount of liquid reaching the abomasum per day may be in part responsible for the results. Although the correction factor may lead to some errors in the absolute values estimated, the comparison or the relative difference among the treatments are thought to be valid.

The amount of ammonia nitrogen in the abomasal digesta was higher ($P<.05$) for the treatments containing SRU as expected. Little soluble nitrogen is present in the HFM according to data presented by Owens (1978). Non-ammonia nitrogen was higher ($P<.05$) in the SRU30 treatment; this may have resulted from the higher intake of dry matter in this treatment permitting more protein to bypass the rumen.

Hydrolyzed feather meal showed less microbial protein synthesis and more bypass ($P<.05$) than the SRU containing treatments; however, this apparently had no effect on nitrogen retention. Percent microbial nitrogen, bypassed nitrogen and microbial protein synthesized per 100 g of dry matter digested in the rumen were not significantly different for the treatments.

Under the conditions of this experiment methionine apparently was not the limiting factor for maximum nitrogen utilization. The requirement of this amino acid may have been met by the diet and further additions caused no effect on nitrogen utilization.

Literature Cited

Kropp, J. R., 1977, J. Anim. Sci. 45:844.

Owens, F. N., 1978a, Feedstuffs 50(28):23.

Comparison of *In Vivo* Nylon Bag Dry Matter and Organic Matter Digestibility of Oklahoma Range Forages During Different Seasons

R. A. Ball, D. G. Wagner and Jeff Powell

Story in Brief

Central Oklahoma native range forage samples were collected from April through December to determine seasonal compositional changes and the relationship or correlation of *in vivo* nylon bag dry matter digestibility (DMD) to nylon bag organic matter digestibility (OMD). Forage samples were "hand separated" into live and dead vegetation during May, June, July and September (growing season). During the non-growing season (April, October, November and December) samples were identified as standing dead vegetation (STDV). Samples (ground through 2 mm screen) weighing 3 g were placed in 100 mesh nylon bags and incubated in the rumen for 48 hr in fistulated steers grazing native range. The DMD and OMD correlation coefficients ranged from .9432 to .9941 even though differences in ash digestion were recorded. The data obtained suggest that either DMD or OMD may be used about equally well in determining forage quality.

Introduction

Forage quality is often measured by *in vivo* or *in vitro* dry matter digestibility studies. Variations in ash content of forages may influence *in vivo* nylon bag dry matter digestibility (DMD) values of forages when attempting to assess forage quality. Ash content of forages might vary due to plant maturity, contamination with dust, soil (particularly during different seasons), or other factors. Perhaps, forage quality could be more accurately assessed by measuring organic matter rather than dry matter digestibility when evaluating range forages throughout different seasons. Hence, the major purpose of this study was to determine the correlations between DMD and OMD of Oklahoma native range forages throughout different seasons.

Materials and Methods

Forage samples were collected throughout the year from a native range watershed located at the northwest end of Lake Carl Blackwell in Noble County, Oklahoma. Forage samples were "hand separated" into live and dead vegetation during May, June, July and September (growing season). During the non-growing seasons (April, October, November and December) samples were identified as standing dead vegetation (STDV). Nylon bag *in vivo* dry matter digestibilities (DMD) were determined monthly on the forage samples to coincide with the time of forage collections. The nylon bag material used was 100 mesh.

Three Holstein steers (544 kg) were fitted with rumen cannulas for the purpose of running the nylon bag *in vivo* digestion trials. The fistulated steers grazed native range at the time of the *in vivo* trials. Three g samples of forage were put in nylon bags, and the bags placed in the rumen for an incubation period of 48 hr. After 48 hr the bags were removed, dried at 55 C for 48 hr and weighed. Dry matter digestibility was calculated as disappearance during ruminal incubation.

Ash content was determined on the forage samples prior to placing in the nylon bags in the rumen and after 48-hr incubation. For ash determination, a 1 g sample was weighed into a porcelain crucible and incinerated at 600 C for four hr.

Nylon bag *in vivo* organic matter digestibility (OMD) was calculated as organic matter (ash free) disappearance during incubation. Organic matter was assumed to be dry matter in the sample minus ash (determined on samples before and after incubation).

Results and Discussion

Dry matter (DMD) and organic matter digestibility (OMD) values are presented in Table 1 for April through December along with correlation coefficients. DMD values of the live forage were 49.1, 46.4, 48.4 and 42.5 percent for May, June, July and September, respectively. OMD values for the same forages were 50.6, 48.1, 49.6 and 45.0 percent during the same months, respectively. DMD for the standing dead vegetation was 28.6, 42.0, 23.5 and 14.7 percent during April, October, November and December, respectively, and OMD was 28.4, 43.5, 22.2 and 17.7 percent during the same months. Correlations between DMD and OMD for April, May, June, July,

Table 1. Dry matter digestibility and organic matter digestibility values with correlation coefficients.

Month collected	Forage	Nylon bag DMD	Nylon bag OMD	Correlation coefficient
		%	%	
April	STDV	28.6	28.4	.979
May	LIVE	49.1	50.6	.990
June	LIVE	46.4	48.1	.989
July	LIVE	48.4	49.6	.995
September	LIVE	42.5	45.0	.964
October	STDV	42.0	43.5	.994
November	STDV	23.5	22.2	.973
December	STDV	14.7	17.7	.943

Table 2. Ash compositions of forage samples prior to and following 48-hr nylon bag ruminal digestion.

Month collected	Forage	Ash content of forage prior to incubation	Ash content following incubation	Mean ash content when bags were inserted[b]	Mean ash content when bags were removed[c]
		%	%	g	g
April	STDV[a]	9.1	14.1	.255	.301
May	LIVE	7.6	10.9	.208	.153
June	LIVE	7.7	10.8	.214	.160
July	LIVE	6.8	9.0	.185	.128
September	LIVE	7.2	12.0	.194	.187
October	STDV	7.1	9.6	.197	.154
November	STDV	8.5	9.4	.240	.205
December	STDV	7.5	10.4	.213	.241

[a]Standing dead vegetation.
[b]Ash in forage placed into nylon bags at beginning of ruminal incubation.
[c]Ash in forage at time nylon bags were removed following 48-hr ruminal incubation.

September, October, November and December were .979, .990, .989, .995, .964, .994, .973 and .943, respectively. Ash content of the forage samples, prior to and after ruminal incubation in the nylon bags, is shown in Table 2. Ash content of the forage ranged from 6.8-9.1 percent prior to incubation and from 9.4-14.1 percent following incubation. Ash disappearance from the nylon bags ranged from positive to negative. Ash may arise not only from minerals in the forage, but soil contamination due to dust, wind, etc. Nevertheless, the high correlations in these data suggest that relative differences in the forage quality of native ranges, as measured by *in vivo* digestibility, can be determined about equally well using either DMD or OMD.

Cattle Breeds, Feedlot Performance and Carcass Characteristics

F. N. Owens, D. R. Gill, J. J. Martin, J. C. Hillier and D. E. Williams

Story in Brief

Gain and carcass measurements of steers from four past trials were sorted by breed. Overall feedlot gain favored the Angus by Hereford (AH) crossbred steers over the Angus (A) and Hereford (H) by 8.4 percent. Herefords gained less rapidly than either A or AH the first 40 to 60 days but more rapidly than A during the remainder of the 117 to 167-day trials. Rib eye area per hundred lb of carcass and cutability favored A. AH had slightly more fat over the rib eye and a poorer yield grade.

Marbling and federal grade favored A over AH and AH over H. The percent of steers grading low choice or above for A was 88 percent, for AH was 70 percent and for H was 54 percent. Percentage of steers grading choice plateaued for all breeds at about 1100 lb live weight. How carcass characteristics changed with carcass weight depended on breed.

Introduction

Performance and carcass characteristics of 618 feedlot steers from four past trials were sorted by breed into three classes: Angus (A), Angus by Hereford crossbred (AH) and Hereford (H). Feedlot performance for the first 40 to 60 days and subsequently in the 117 to 167-day feeding trials was available. Steers for all trials were obtained as feeder calves or yearlings from similar weight groups entering feedlot pens in Guymon, Oklahoma. No information on age or specific background of the steers is available, but the cattle should represent a typical sampling of steers available for feeding in the Great Plains.

Groups were slaughtered at a constant number of days on feed with no sorting by breed. Although 13 different breeds or crosses were visually identifiable in these trials, insufficient numbers of other breeds and crosses were available for analysis. The alteration in carcass characteristics for every 100 lb change in carcass weight was calculated.

Table 1. Breed effects, weighted averages.

Item	Breed		
	Angus	A x H Cross	Hereford
Number of steers	185	186	247
Initial weight	695	731	710
Daily gain			
Initial			
(First 41-56 days)	3.94[b]	4.05[b]	3.68[a]
Later			
(to slaughter)	2.94[a]	3.29[c]	3.02[b]
Total	3.36[a]	3.62[b]	3.32[a]

[abc]Means with similar superscripts do not differ statistically (P<.05).

Table 2. Breed effects, weighted averages.

Item	Breed		
	Angus	A x H Cross	Hereford
Dressing, %	61.9[a]	62.5[b]	61.7[a]
Carcass weight, #	706	730	703
Rib eye area			
Sq in	12.67[b]	12.62[b]	12.28[a]
Sq in/cwt	1.80[b]	1.74[a]	1.75[a]
Cutability[d], %	49.86[b]	49.23[a]	49.43[a]
KHP, %	3.05	3.05	3.00
Fat over rib eye, in	.50[a]	.56[b]	.53[ab]
Liver abscess score	.62	.49	.72
Yield grade	3.27[ab]	3.34[b]	3.22[a]
% yield grade 4 & 5	9.7	12.4	6.5
Marbling score[e]	15.28[c]	14.03[b]	12.86[a]
Quality grade[f]	13.31[c]	12.59[b]	12.18[a]
Percent choice[g]	87.6[c]	69.9[b]	53.8[a]

[abc]Means with similar superscripts do not differ statistically (P<.05).
[d]From standard formula.
[e]Slight = 11; slight plus = 12; small minus = 13.
[f]Good = 11; high good = 12; low choice = 13.
[g]Percentage of carcasses with quality grade above low choice.

Results and Discussion

Performance characteristics by breed are presented in Table 1. Initial weights were slightly greater for AH steers than H and A steers. Rate of weight gain the first 41 to 56 days was slower for H than A and AH. Later, gains of AH exceeded both H and A steers. No index of feed intake or feed efficiency is available. Rate of gain by AH steers exceeded the purebred mean by 8.4 percent. Animal breeders expect about half this response from heterosis. The remainder may be a result of more stringent selection of sires by livestock breeders producing crosses rather than straight-bred cattle.

Carcass characteristics by breed are presented in Table 2. Dressing percentage was higher for AH, possibly due to the heavier carcass weight. These dressing percentages are hot carcass weight divided by *full* weight, not shrunk weight. Rib eye area, in

Table 3. Weight, breed, grade and yield.

Live Weight	Dressing	Carcass weight	Percent choice[d]			% yield 4 & 5[e]		
			A	A x H	H	A	A x H	H
#	%	#						
966	59.5	575	75[b]	—	12.5[a]	17	0	0
1040	60.1	625	80[b]	59.1[ab]	43.8[a]	0	0	3
1090	61.9	675	95.5[c]	72.7[b]	56.5[a]	9[b]	12[b]	1[a]
1166	62.2	725	88.9[c]	71.7[b]	57.7[a]	13	10	10
1228	63.1	775	84.2[b]	70.0[ab]	59.5[a]	11	10	14
1314	62.8	825	90.9[b]	70.0[ab]	53.8[a]	9[a]	30[b]	15[a]

[abc]Means in a row in a group differ statistically.

[d]Quality grade was largely dependent on marbling of the rib eye in these studies.

[e]Poor yield grades, over 4, were largely caused by excessive fat thickness over the rib eye in these studies.

square inches, was smallest for H. Expressed as area per hundred lb of carcass, A were superior. Cutability, an index of the lean cuts available for the consumer, favored A. Although internal fat (kidney, heart and pelvic) differed little by breed, fat over the rib was greater for AH than A. Yield grade was higher for AH than H and a few more AH fell into the yield 4 and 5 category.

Marbling score, one of the primary factors in federal quality grade, was greater for A than AH and greater for AH than H. The percentage of carcass graded low choice or above was 88 percent for A, 70 percent for AH and 54 percent for H.

Commonly, to improve marbling, steers are fed to heavier weights. Carcass grades for the breeds at different weights are presented in Table 3. As live weight increased, dressing percent increased, but the percent of steers grading choice had virtually plateaued by the 1090 lb live weight. Superiority of A over AH and AH over H in quality grade was apparent at all but one carcass weight. Percent of carcasses graded 4 or 5 tended to increase with weight.

Further relationships of carcass measurements to carcass weight are presented in Table 4. As an example, if steers are fed to gain an extra 100 lb of carcass, one might expect 8 percent more to grade choice, but 21 percent more would fall into the yield 4 and 5 category. Indices of growth (rib eye area) and fat increased with carcass weight for all breeds, but marbling and quality grade did not increase with weight for A steers as it did for H and HA. Because of these differences, relative values between breeds for cattle feeding will depend on current grading standards, the economics of long or short term feeding and relative discounts for grade or yield.

Table 4. Carcass changes with carcass weight.

Item	Change per 100 # carcass	Breed differences
Rib eye area, in^2	+ .792	No
Cutability, %	− 1.14	A<H, HA
KHP, %	+ .17	No
Fat over rib eye, in	+ .12	A<H, HA
Yield grade	+ .22	No
% yield grade 4 & 5	+20.6	No
Marbling score	+ .71	A<H, HA
Quality grade	+ .33	A<H, HA
Percent choice	+ 8.2	A<H, HA

The Influence of Variety on Nutritive Characteristics of Grain Sorghum

C. A. Hibberd, D. E. Weibel, R. L. Hintz and D. G. Wagner

Story in Brief

The nutritive characteristics of eight varieties of finely ground grain sorghum representing four seed classes (Waxy, Waxy-BR, Normal, Normal-BR) (BR = bird resistant) were studied utilizing *in vitro* dry matter disappearance (DMD) and *in vitro* gas production (GP) procedures. All grains were finely ground through a 20-mesh screen. Waxy sorghums were generally higher in DMD and GP than Normal-BR sorghum varieties. Sorghum from the Waxy-BR and Normal seed classes were intermediate in value. Significant differences, however, were also observed within Waxy and Normal-BR seed classes. These studies show there are significant differences in nutritive characterisitics due to variety when sorghum grains are finely ground.

Introduction

During recent years, drought conditions, water conservation, high production costs, insects, diseases, etc. have caused a shift in grain production to less corn and more sorghum in the Southern Great Plains. Sorghum, therefore, is a major feed grain for cattle in this area. One of the greatest problems with grain sorghum is its highly variable and generally lower feeding value in relation to corn. For these reasons among others, sorghum is generally discriminated against by cattle feeders. Some variability may be due to environmental conditions during growth and maturation of the grain.

Previous studies have indicated that sorghum variety or endosperm type can also account for some of the variation. Hibberd *et al.* (1978) suggested that varieties of grain sorghum differed in nutritive characteristics as evidenced by *in vitro* dry matter disappearance studies for grains grown in two consecutive crop years. The purpose of this study was to further evaluate the nutritive characteristics of several grain sorghum varieties grown in Year 3.

Materials and Methods

Eight varieties of grain sorghum representing four different seed classes were grown and harvested under dryland conditions at the Perkins Agronomy Research Station. This crop represented the third of three consecutive crops of grain sorghum studied at this station. Descriptive characteristics and classification of the grain sorghum varieties are presented in Table 1. The varieties were classified by seed class which differentiates between waxy or normal (nonwaxy) endosperm and bird resistant (brown seed coat) or non-bird resistant grains.

Prior to evaluation, all grain samples were finely ground through a 20-mesh screen in a laboratory Wiley mill. Chemical composition of the grain samples was determined using conventional procedures. Total starch content was determined according to the procedure outlined by Macrae and Armstrong (1968). *In vitro* dry matter disappearance (DMD) was obtained utilizing strained rumen fluid from a concentrate-fed steer. Percent DMD was determined by difference after a 24-hr incubation.

In vitro gas production (GP) studies were performed as a measure of starch availability of the grains. Commercial baker's yeast and an enzyme solution (amyloglucosidase) were placed in 50 ml erlenmeyer flasks along with the grain sample. Gas

Table 1. Descriptive characteristics and classification of sorghum grains (Year 3).

Variety	Seed coat color	Endosperm characteristics: Color	Hardness	Waxy or normal	Classification
Dwarf Redlan	Red	White	Intermediate	Waxy	
73BCT 1122-2	Red	Yellow	Intermediate	Waxy	Waxy
73BCT 1126	White	Yellow	Intermediate	Waxy	
73BCT 1133-2	Brown	Yellow	Intermediate	Waxy	Waxy-BR
Redlan Normal	Red	White	Intermediate	Normal	Normal
Soft Endo	Brown	White	Soft	Normal	
Darset	Brown	White	Intermediate	Normal	Normal-BR
ROKY 78	Brown	Yellow	Intermediate	Normal	

Table 2. Chemical composition of whole grains %.

	Protein	Ether Extract	Ash	Starch
Waxy				
Dwarf Redlan	11.50[a]	2.70	1.56	79.5[a]
1122	12.61[b]	1.55	1.54	74.5[a]
1126	16.30[c]	1.67	2.24	66.6[b]
Waxy-BR				
1133	12.02[d]	1.69	1.84	75.7[a]
Normal				
Redlan	13.78[e]	2.72	1.64	77.1[a]
Normal-BR				
Soft Endo	13.76[e]	2.88	1.57	72.0[a,b]
Darset	11.40[a]	1.30	1.55	79.0[a]
ROKY	11.66[a]	2.48	1.30	77.8[a]
Overall average	12.88			75.26

[a,b,c,d,e]Means with different superscripts are significantly different ($P<.05$).

production was measured as ml of gas produced per gram of dry matter via an inverted buret recovery system. Results were subjected to an analysis of variance according to Steel and Torrie (1960), and differences were determined using Tukey's HSD protected by a preliminary F test.

Results and Discussion

The chemical compositon of the whole grains is presented in Table 2. Crude protein content varied significantly among varieties within the Waxy seed class, ranging from 16.30 percent for 1126 to 11.50 percent for Dwarf Redlan. Significant differences were also noted among the other varieties with protein content ranging from 11.40 percent for Darset (Normal-BR) to 13.7 percent for Redlan (Normal). Starch content was statistically similar across all varieties (72.0 to 79.5 percent), except for the Waxy 1126 (66.6 percent) being significantly lower ($P<.05$) than the others. This variety was the highest in protein and the lowest in starch.

Figure 1 illustrates 24-hr DMD values. The Normal-BR varieties all showed statistically similar DMD (46.2 to 49.1 percent) values ($P>.05$), but were significantly lower ($P<.05$) than the other varieties. The other varieties ranged from 61.6 percent for Dwarf Redlan Waxy to 54.7 percent for the Waxy-BR variety 1133. Others were intermediate, but significant.

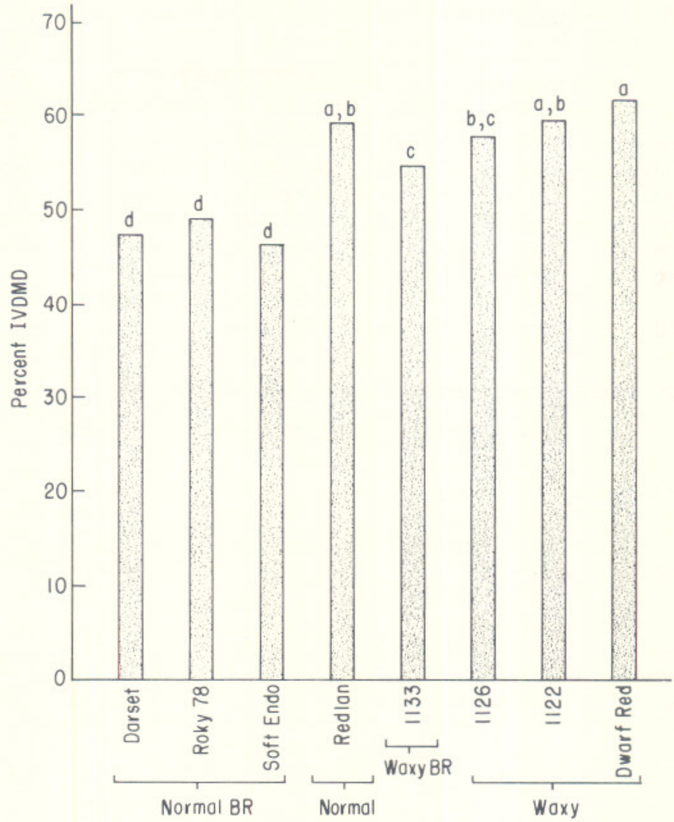

Figure 1. 24-hour DMD of finely ground grain sorghum (Year 3).

In vitro gas production data (Figure 2) also suggests differences in starch availability by variety. Starch availability for two of three Normal-BR varieties (Darset and ROKY 78) was significantly lower ($P<.05$) than for the other varieties tested. The Dwarf Redlan and 1122 Waxy varieties showed the highest GP ($P<.05$). The Waxy-BR and Normal varieties were generally intermediate and different from Waxy and Normal-BR. The lower value observed for 1126 may be a reflection of its lower starch and higher protein content. Interestingly, one of the Normal-BR varieties (Soft Endo) showed a GP value as statistically high as the two best Waxy varieties (Dwarf Redlan and 1122). The elevated GP value for the Soft Endo (although BR) is probably due to a weaker endosperm structure associated with the soft endosperm. The high starch availability of the Waxy-BR is probably due to the effect of the waxy endosperm mediated slightly by the effect of the brown seed coat.

The nutritive value of the grains studied in Year 3 reflect patterns similar to those observed in two previous years. The DMD values reflect differences primarily related to Waxy versus Nonwaxy endosperm and brown versus non-brown seed coats. This classification system appears to account for a large proportion of the variability among varieties. The GP values follow a similar pattern but appear to be mediated, to some extent, by other factors such as endosperm hardness.

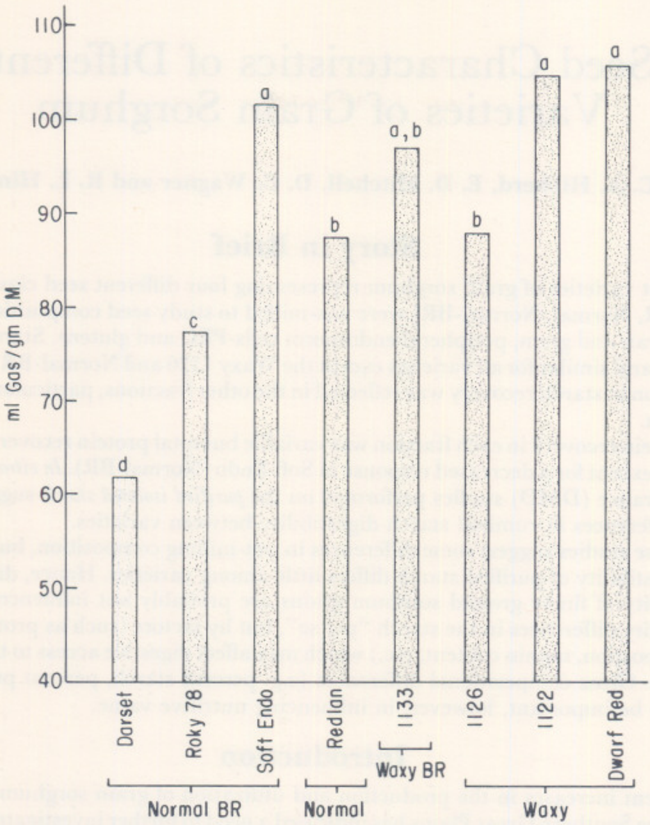

Figure 2. 12-hour gas production of finely ground grain sorghum (Year 3).

The improved nutritive characteristics observed for the Waxy Bird Resistant 1133 is indicative of some of the potential genetic benefits which are possible in upgrading sorghum varieties for nutritive value while maintaining certain desirable agronomic features such as bird resistance. Significant differences in digestibility between sorghum varieties may partially explain the variations observed in feeding value of this grain. Environmental conditions during growth and processing effects before feeding may aggravate or mediate varietal effects although such theories have not been adequately considered. In brief, the effect of variety appears to be an important variable in determining the nutritive value of grain sorghum.

Literature Cited

Hibberd, C. A., R. Schemm and D. G. Wagner. 1978. Influence of endosperm type on the nutritive value of grain sorghum and corn. Okla. Agr. Exp. Sta. MP-103:77.

Macrae, J. C. and D. G. Armstrong. 1968. Enzyme method for determination of -linked glucose polymers in biological materials. J. Sci. Fd. Agr. 19:578.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Seed Characteristics of Different Varieties of Grain Sorghum

C. A. Hibberd, E. D. Mitchell, D. G. Wagner and R. L. Hintz

Story in Brief

Eight varieties of grain sorghum representing four different seed classes (Waxy, Waxy-BR, Normal, Normal-BR) were wet-milled to study seed composition (percent starch, bran and germ, peripheral endosperm cells-PEC and gluten). Starch recovery was high and similar for all varieties except the Waxy 1126 and Normal-BR ROKY 78. Depression in starch recovery was reflected in the other fractions, particularly the bran and germ.

Protein recovery in each fraction was variable but total protein recovery was fairly constant except for a decreased response in Soft Endo (Normal-BR). *In vitro* dry matter disappearance (DMD) studies performed on the *purified isolated starch* suggested only small differences in ruminal starch digestibility between varieties.

These studies suggest some differences in wet-milling composition, but that the *in vitro* digestibility of purified starch differs little among varieties. Hence, differences in digestibility of finely ground sorghum grains are probably not influenced much by digestibility differences in the starch "per se", but by factors (such as protein content and compostion, tannin content, etc.) which may affect digestive access to the starch in the grain. Gross compositional differences (e.g. percent starch, percent protein, etc.) may also be important, however, in influencing nutritive value.

Introduction

Recent increases in the production and utilization of grain sorghum as a cereal crop in the Southern Great Plains has indicated a need to further investigate differences in feeding quality of sorghums for ruminants. One of the greatest concerns in using grain sorghum in feeding programs is the variability often associated with this grain. Some variability may be caused by environmental factors such as rainfall or soil fertility. A major portion of the variability might also be attributed to variety of the grain sorghum. Varietal effects should be related to one of the major seed components such as starch, protein or tannins, alone or in combination. Therefore, the purpose of this study was to further investigate the seed characteristics of different varieties of grain sorghum grown in Year 3.

Materials and Methods

Eight different varieties of grain sorghum were grown and harvested under dryland conditions for a third consecutive year (Year 3). These varieties included four with Waxy endosperms: Dwarf Redlan, BCT 1122-2, BCT 1126 and BCT 1133-2. The 1133 also had a brown seed coat indicating bird resistance. The other four varieties were of the Normal (Nonwaxy) endosperm: Redlan, Soft Endo, Darset and ROKY 78. All of these varieties were bird resistant except the Redlan. These characteristics are summarized in Table 1.

A laboratory wet-milling procedure as outlined by Ackerson *et al.* (1978) was utilized to separate the sorghum kernels into four components: bran and germ, peripheral endosperm cells, gluten and purified starch. The bran and germ consists of

Table 1. Descriptive characteristics of grain sorghum varieties (Year 3).

Variety	Waxy	Bird resistant	Seed class
Dwarf Redlan	yes	no	Waxy
BCT 1122-2	yes	no	Waxy
BCT 1126	yes	no	Waxy
BCT 1133-2	yes	yes	Waxy-BR
Redlan	no	no	Normal
Soft Endo	no	yes	Normal-BR
Darset	no	yes	Normal-BR
ROKY 78	no	yes	Normal-BR

the outer seed coat surrounding the endosperm and the germ portion of the seed. The peripheral endosperm cells (PEC) originate primarily from the outer portion of the endosperm which is the location of the dense protein matrix. The gluten consists of protein bodies from the floury endosperm plus fragmentary protein from all portions of the seed. The final component is the purified raw starch which has been isolated in its native granular state. After wet-milling, all components were dried and expressed as a percentage of the original sample. Each component was then analyzed for crude protein utilizing the Kjeldahl procedure. Protein content is expressed as a proportion of total protein recovered in each fraction.

A 24-hr *in vitro* dry matter disappearance (DMD) study was run on the purified starch. A 0.2 g sample of each starch was incubated in strained rumen fluid and buffer solution. Twenty mg of urea was added to each tube to simulate crude protein levels in the intact seed. Dry matter disappearance was determined by difference after a 24-hr incubation period. The data was subjected to an analysis of variance and differences were determined using Tukey's HSD test for multiple comparisons as outlined in Steel and Torrie (1960).

Results and Discussion

Wet-milling composition of the Year 3 grain sorghums is presented in Table 2. The starch isolated was similar for all varieties (56.98-61.31 percent) except for the Waxy 1126 (50.46 percent) and the Normal-BR ROKY 78 (54.57 percent). The lower quantities of starch recovered for the 1126 and ROKY 78 are reflected in the highest content ($P<.05$) of bran and germ for these two varieties. Bran and germ recovery was similar for the other varieties (16.68-19.36 percent) although some significant differences were observed. The grains differed significantly in PEC content ranging from 1.75 percent for the 1133 to 4.80 percent for the Redlan. Although these differences are significant, the PEC fraction does not account for a large proportion of the kernel. Nevertheless, the PEC fraction may have an important influence upon starch digestibility in the rumen and/or intestine in that the PEC fraction represents the dense protein matrix surrounding the starch granules. A heavy, dense matrix may make accessibility to the starch granules more difficult, lowering starch digestion. Some significant differences were observed in gluten recovery; however, no predictable patterns were discernable. The wet-milling composition trends were generally small and difficult to define. This data illustrates that differences in wet-milling composition across varieties do occur and may contribute to variability in grain sorghum.

Crude protein recovery in each wet-milling fraction is presented in Table 3. Crude protein recovery in each fraction differed by variety, but, differences were not easily characterized. Total protein recovery, however, was similar for all varieties except the Soft Endo. The depressed protein recovery for Soft Endo may be associated with the weakened matrix of the kernel resulting in a higher amount of soluble protein.

Table 2. Wet-milling compositional characteristics (Year 3).

	% Starch	% Bran & Germ	% PEC	% Gluten
Waxy				
Dwarf Redlan	61.31[a]	16.68[d]	2.50[b,c,d]	12.12[b,c]
BCT 1122-2	58.41[a,b]	19.36[c]	2.32[c,d]	11.04[c]
BCT 1126	50.46[d]	24.85[a]	2.14[c,d]	13.14[a,b]
Waxy BR				
BCT 1133-2	58.34[a,b]	17.16[d]	1.75[d]	14.72[a]
Normal				
Redlan	56.98[b,c]	18.08[c,d]	4.80[a]	13.20[a,b]
Normal BR				
Soft Endo	58.58[a,b]	18.66[c,d]	2.05[d]	10.53[c]
Darset	60.57[a]	17.87[c,d]	3.40[b]	13.32[a,b]
ROKY 78	54.57[c]	22.12[b]	3.14[b,c]	14.28[a]

[a,b,c,d]Means in a column with different superscripts are significantly different ($P<.05$).

Table 3. Protein recovery in various wet-milling fractions.[a]

	Bran and germ	PEC[b]	Gluten	% of total recovered[c]
Waxy				
Dwarf Redlan	24.87	6.09	44.26	75.22
73 BCT 1122-2	29.02	6.11	40.44	75.57
73 BCT 1126	30.86	6.07	41.23	78.16
Waxy-BR				
73 BCT 1133-2	23.79	3.66	50.00	77.45
Normal				
Redlan	22.42	9.07	42.96	74.45
Normal BR				
Soft Endo	20.93	5.23	38.44	64.60
Darset	27.19	8.24	45.96	81.39
ROKY 78	29.76	6.60	42.37	78.73

[a]Presented as grams recover ÷ total grain protein (grams) × 100.

[b]Peripheral endosperm cells.

[c]Percent of total recovered in Bran and germ, PEC and Gluten fractions. Remainder would be in the steeps due to soluble protein components present in the grains or solubilization of protein during the steeping process. One of the purposes of steeping is to loosen the protein matrix for ease of starch granule recovery during the wet-milling process.

Figure 1 illustrates the DMD response of the various *purified, raw isolated* starches. All starches were statistically ($P>.05$) similar with an overall average of 53.5 percent. No trends favoring the high amylopectin Waxy starches were apparent. The DMD response suggests that rumen microorganisms may not show a marked preference for the type of sorghum starch presented to them once access to the starch granules has been achieved. More difficulty may exist, however, in acquiring access to the starch granules in some types of sorghum. If this premise is correct, then differences in the feeding value of different sorghum varieties may also be associated with other factors, such as protein or tannin effects.

In conclusion, wet-milling data suggests that wet-milling composition differs across varieties, but these differences do not appear to be the only ones which contrib-

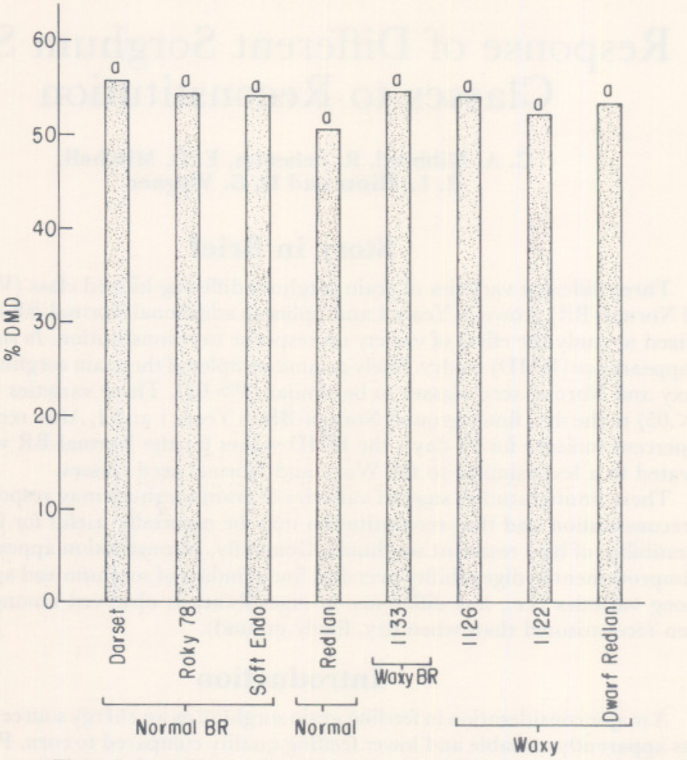

Figure 1. 24-hour DMD of raw, isolated starch (Year 3).

ute to total variability. Finally, differences in DMD of *isolated, raw starch* were not observed, suggesting that starch type (once access to the starch granules is obtained) may not have a large effect on ruminal digestibility.

Literature Cited

Ackerson, B., R. Schemm and D. G. Wagner. 1978. Seed characteristics of different sorghum endosperm types. Okla. Agr. Exp. Sta. MP-103:82.

Response of Different Sorghum Seed Classes to Reconstitution

C. A. Hibberd, R. Schemm, E. D. Mitchell,
R. L. Hintz and D. G. Wagner

Story in Brief

Three different varieties of grain sorghum differing in seed class (Waxy, Normal and Normal-BR) grown in Years 1 and 2 plus an additional Normal-BR in Year 3 were utilized to study the effect of variety on response to reconstitution. *In vitro* dry matter disappearance (DMD) on dry, finely ground samples of the grain sorghum showed the Waxy and Normal seed classes to be similar ($P>.05$). These varieties were superior ($P<.05$) to the dry, finely ground Normal-BR in Years 1 and 3. After reconstitution to 30 percent moisure for 21 days, the DMD values for the Normal-BR were generally elevated to a level similar to the Waxy and Normal seed classes.

These limited studies suggest varieties of grain sorghum may respond differently to reconstitution and that reconstitution may be especially useful for improving the digestibility of bird resistant sorghums. Generally, reconstitution appears to produce an improvement in digestibility over dry, fine grinding of sorghum and an equalization among varieties (i.e., less difference in digestibility is observed among seed classes when reconstituted than when dry, finely ground).

Introduction

A major consideration in feeding grain sorghum as an energy source for ruminants is its apparently variable and lower feeding quality compared to corn. Possibly, much variability is due to the effect of variety or seed type. The effect of variety as mediated by grain processing is an area that is not well understood. Variable responses to processing of grain sorghum have been observed in many trials. The effect of variety may alter the processing response due to large variation among varieties.

The process of reconstituting grain sorghum to about 30 percent mositure and storing for 21 days under anaerobic conditions has been studied extensively. Reconstitution has often given a highly favorable response but the magnitude of the response has been variable. Generally, most trials do not report the variety or type of grain sorghum utilized. Therefore, variability may be due, at least in part, to varietal effects. Consequently, the purpose of this study was to examine the response of varieties differing widely in nutritive characteristics to reconstitution.

Materials and Methods

Three grain sorghum varieties in Years 1 and 2 and four varieties in Year 3 were utilized to study reconstitution response. All grains were grown under similar dryland conditions for three consecutive years. Varieties and seed classifications are illustrated in Table 1.

A 200 g sample of whole grain was reconstituted to 30 percent moisture, placed in glass bottles, gassed with CO_2 and stored for 21 days. After the reconstitution period, each sample was ground through a 20-mesh screen in a laboratory Wiley mill prior to analysis. Dry ice was utilized to facilitate the grinding of the wet samples. Untreated grain from each variety was also finely ground (20-mesh screen) for analysis and comparison with the reconstituted grains.

In vitro dry matter disappearance (DMD) studies were used to measure ruminal digestibility of the grains. Fresh rumen fluid from a concentrate-fed steer was strained, mixed with buffer and placed in 50-ml centrifuge tubes containing 0.4 g of the ground sample. DMD was determined by difference after a 24-hr incubation period. All data were subjected to an analysis of variance according to Steel and Torrie (1960). Differences between means were detected using Tukey's HSD procedure protected by a preliminary F-test.

Results and Discussion

In vitro dry matter disappearance (DMD) studies indicated that the reconstitution process produced a favorable response in all three years. In Years 1 and 3 (Figures 1 and 3) the dry, finely ground Normal-BR sorghum had a significantly lower ($P<.05$) DMD than the Waxy or Normal seed classes. The Normal-BR was also lowest in Year 2

Table 1. Descriptive characteristics of grain sorghum varieties.

Variety	Bird resistant	Waxy	Seed class
Dwarf Redlan	no	yes	Waxy
Redlan	no	no	Normal
Darset	yes	no	Normal-BR
ROKY 78*	yes	no	Normal-BR

*ROKY 78 represented only in Year 3.

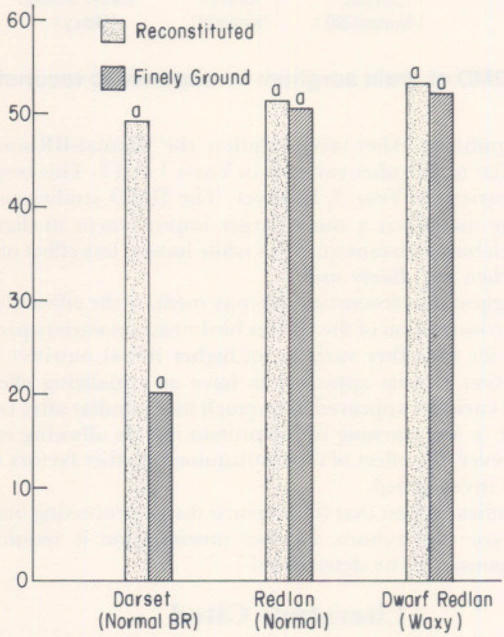

Figure 1. 24-hour DMD of grain sorghums in response to reconstitution (Year 1).

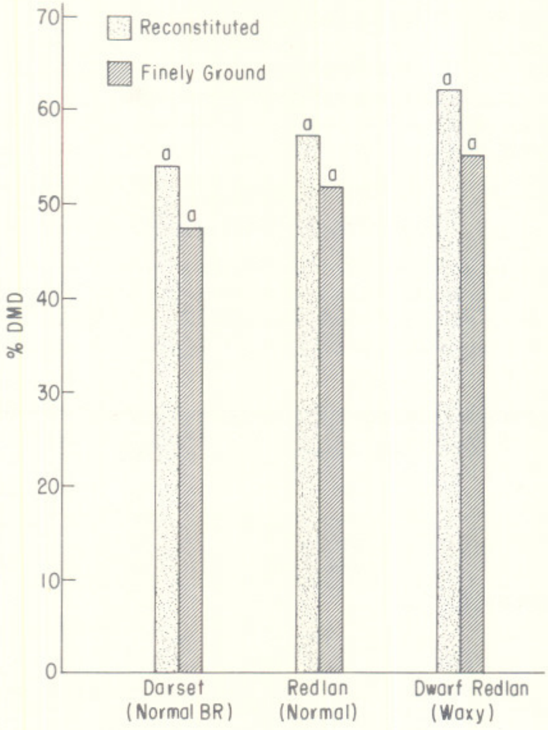

Figure 2. 24-hour DMD of grain sorghum in response to reconstitution (Year 2).

(Figure 2) but not significant. After reconstitution, the Normal-BR was elevated to a level statistically similar to the other varieties in Years 1 and 2. This response was true for only the Darset variety in Year 3, however. The DMD studies suggest that the reconstitution process may elicit a much larger improvement in digestibility from sorghum varieties with bird resistant qualities while having less effect on varieties that are better digested when dry, finely und.

These studies suggest that reconstitution may mediate the effect of varietal differences. Specifically, reconstitution of the Darset bird resistant variety produces a much larger response than for the other varieties of higher initial nutritive value. In this study, the reconstitution process appeared to have an equalizing effect in that the digestibility across all varieties appeared to be much more similar after treatment. This effect is probably due to a weakening of the protein matrix allowing easier access to starch granules. However, the effect of reconstitutuion on other factors such as tannin content has not been investigated.

These limited studies suggest that the response due to processing may be mediated by variety or seed type of sorghum. Further investigation is required before the generality of this response can be determined.

Literature Cited

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

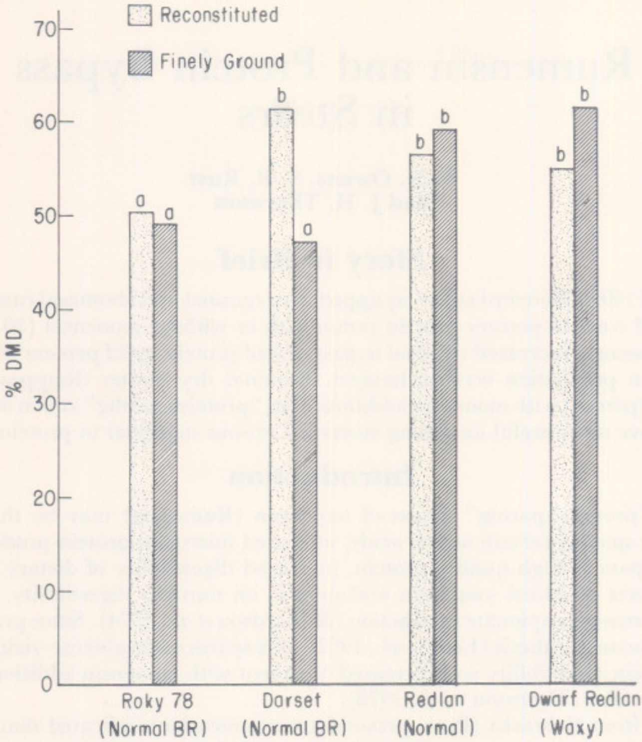

Figure 3. 24-hour DMD of grain sorghums in response to reconstitution (Year 3).

Rumensin and Protein Bypass in Steers

**F. N. Owens, S. R. Rust
and J. H. Thornton**

Story in Brief

Four 1100 lb Hereford steers equipped with ruminal and abomasal cannulas were fed a rolled corn 16 percent protein ration with or without monensin (30 g per ton) added. Monensin increased ruminal bypass of feed protein by 22 percent while microbial protein production was unchanged. Ruminal dry matter disappearance was reduced 16 percent with monensin addition. This "protein sparing" action of monensin should prove most useful for young steers fed rations marginal in protein.

Introduction

The "protein sparing" action of monensin (Rumensin) may be the result of propionate sparing certain amino acids, increased microbial protein production, enhanced bypass of high quality protein, increased digestibility of dietary protein or similar effects of added monensin and protein on nutrient digestibility. Monensin feeding increases propionate production (Richardson *et al.*, 1974). Since propionate is used for glucose synthesis (Leng *et al.*, 1967), this spares some glucose-yielding amino acids. Protein digestibility was increased 4 percent with monensin addition to a high concentrate diet (Thornton *et al.*, 1978).

Work from Nebraska (Poos, personal communication) indicated that monensin decreases microbial protein production in the rumen but increases bypass of protein to the lower gastrointestinal tract. The objective of this study, which was previously reported in abstract form (Owens *et al.*, 1978), was to determine the influence of monensin on ruminal protein digestion and microbial protein synthesis.

Materials and Methods

Four 1100 lb steers equipped with ruminal and abomasal cannulas were fed an 80 percent concentrate high protein ration (Table 1) with and without monensin in a crossover design. The steers were fed 6.6 lb of feed twice daily during the first four days of each period. To stabilize non-ammonia nitrogen passage, 500 g of the ration was fed manually every 2 hr the last three days of each period. Polyethylene glycol (75 g) and chromic oxide (30 g) were fed to each steer daily as flow rate markers.

The ration analyzed 16 percent crude protein and 90 percent dry matter. The ration contained extra soybean meal so that differences in protein bypass might be more easily detected. Monensin was added to each day's ration at a rate equivalent to 30 g of monensin per ton of feed. Abomasal and ruminal samples were taken the last two days of each period. The abomasal samples were separated into liquid and solid fractions by centrifugation.

Results and Discussion

Ruminal dry matter digestion was 10 percentage units greater with monensin addition (Table 2). Rumen liquid turnover rates were slightly reduced (24 percent) with monensin feeding (Table 3). The molar percentage of propionate was increased (Table 4) while acetate and isovalerate were decreased with monensin supplementa-

Table 1. Ration composition.

Ration	%
Dry rolled corn	57.0
Dehydrated alfalfa	5.4
Cottonseed hulls	12.6
Soybean meal	19.0
Cane molasses	4.5
TM salt	.5
Ground limestone	.5
Dicalcium phosphate	.5
Urea	.1

Table 2. Ruminal dry matter digestion.

	Monensin	
Item	0	33
Dry matter, g/day		
Feed	5386	5386
Abomasal	2089	2628
Ruminal digestion, %	61	51

Table 3. Rumen turnover %/hr.

	Monensin	
Items	0	33
Liquid	7.4	5.6
Solids	4.9	5.0

Table 4. Ruminal VFA composition.

	Monensin	
Item	0	33
Volatile fatty acid		
Total acid, mM	94.4	100.3
Acetate, molar %	62.2[c]	51.4[d]
Propionate	22.0[c]	36.1[d]
Butyrate	9.7	7.6
Isobutyrate	1.5	1.2
Valerate	1.1	1.3
Isovalerate	2.2[a]	1.4[b]
Acetate/propionate ratio	2.8[c]	1.5[d]
Non-glucogenic ratio	3.8[c]	1.9[d]

[ab]Statistically significant ($P<.075$).
[cd]Statistically significant ($P<.05$).

Table 5. Abomasal protein passage.

	Monensin	
Item	0	33
Feed N, g	138.0	138.0
Abomasal N, g	136.1	157.2
Bacterial N, g	51.2	53.5
Feed N, g	84.9	103.7

Table 6. Ruminal parameters.

	Monensin	
Item	0	33
Rumen		
Ammonia N (mg / %)	14.2	12.4
α-amino N (mM)	22.7	18.6
Soluble protein (mg/m1)	5.0	4.9

tion. Abomasal protein passage was 15.5 percent greater with monensin supplementation (Table 5). Microbial protein outflow from the rumen was unchanged by monensin. Increased bypass of feed protein accounted for all of the increase in abomasal protein passage.

Ruminal nitrogen parameters are given in Table 6. The trend for lower ruminal ammonia and alpha-amino nitrogen suggests that monensin was inhibiting some step in protein breakdown before amino acids were formed. Because monensin decreased protein breakdown in the rumen, it should prove more beneficial with rations marginal in protein as a previous feeding trial (Martin *et al*., 1977) indicated.

Literature Cited

Leng, R. A., J. W. Stal and J. R. Luick. 1967. Biochem. J. 103:785.

Martin, J. J., F. N. Owens, D. R. Gill and J. H. Thornton. 1977. Okla. Agr. Exper. Sta. Res. Rep. MP-101, p. 47.

Owens, F. N., B. J. Shockey, R. W. Fent and S. R. Rust. 1978. ASAS Southern Section Abstract, p. 64.

Richardson, L. F., A. P. Raun, E. L. Potter, C. O. Cooley and R. P. Rathmacher, 1974. J. Anim. Sci. 37:1414.

Thornton, J. H., F. N. Owens and R. W. Fent. 1978. Okla. Agr. Exper. Sta. Res. Rep. MP-103, p. 70.

Ruminal Turnover Rate - Influence of Feed Additives, Feed Intake and Roughage Level

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Story in Brief

Liquid trace mineral (LTM) and bentonite enhanced ruminal turnover rate of liquids while monensin depressed it. Turnover rate increased with feed intake and addition of roughage to a high concentrate ration. Changes in turnover rate of solids tended to parallel liquids. Solid turnover rate was much lower with high roughage rations than high concentrate rations.

Introduction

Solids which leave the rumen undigested often are poorly digested in the intestines, so increased turnover rate may depress digestibility. However, processed grain rations, which can be digested in the intestines, are more efficiently utilized if digested in the intestines than in the rumen. Furthermore, the faster bacteria grow in the rumen, the more efficiently they grow since less energy is wasted for maintenance. Consequently, increased turnover should increase the efficiency of both bacterial protein production and feed use with well processed rations. These studies examined the influence of several additives, intakes and roughage levels on ruminal turnover rates of liquids and solids.

Materials and Methods

Fistulated steers were used in all trials. These ranged in weight from 600 to 1100 lb in different trials. In all trials, steers were rotated among rations so that the comparison between additives or feed composition was not influenced by animal size or weight. Animal numbers varied from trial to trial. Preliminary periods lasted a minimum of seven days and were typically 14 days long. Polyethylene glycol or chromium EDTA served as "markers" to track the liquid fraction and in some trials chromic oxide tracked the solid fraction. Markers were either fed or dosed via cannula. After dosing, a series of samples of rumen contents were obtained from 4 to 30 hr later to calculate outflow. Level of additives, feed intake and roughage are presented in tables with results.

Results and Discussion

The effects of feed additives on rumen turnover rate are shown in Table 1. When LTM was added to the basal ration, liquid turnover rate increased. Niacin also tended to enhance turnover. Changes in turnover rate for the solid phase tended to parallel that of liquid. Addition of bentonite (2 percent of the ration) also increased liquid turnover. In two trials with addition of bicarbonate (1 percent and 1.5 percent), liquid phase turnover declined slightly. Addition of either cement kiln dust (3.5 percent) or Ronnel (.18 lb/ton) slightly decreased liquid turnover rate. Monensin in two trials depressed rumen turnover rate for both liquids and solids. As feed intake increased, from a maintenance to twice maintenance (Table 2), ruminal liquid turnover rate tended to increase at an increasing rate.

Table 1. Feed additives and ruminal turnover.

Ration	Number of animals	Ruminal turnover, %/hr	
		Liquid	Solid
Basal[a]	9	8.34[f]	4.40
1 + LTM	9	9.58[g]	5.45
1 + Niacin	9	9.10[fg]	---
Basal[b]	4	6.70[h]	---
2 + bentonite, 2%	4	7.60[i]	---
Basal	4	6.98	---
2 + bicarbonate, 1%	4	6.71	---
Basal[c]	8	7.32	---
3 + cement kiln dust, 3.5%	8	6.39	---
3 + Ronnel, .18 lb/ton	8	6.69	---
3 + bicarbonate, 1.5%	8	6.50	---
Basal[d]	4	7.40[f]	4.92
4 + monensin (.006 oz/day)	4	5.59[g]	4.39
Basal[e]	16	6.53[h]	2.73[f]
5 + monensin	16	4.52[i]	1.54[g]

[a]11.9 lb/day of ration B010 (17.9 lb DM/day of 63% rolled corn, 10% soy, 14% cottonseed hulls, 6% alfalfa, 5% molasses) fed to 1100 lb steers.
[b]13.9 lb/day of ration B010 fed to 1100 lb steers.
[c]17.9 lb DM/day of B010 ration for 1100 lb steers.
[d]11.6 lb DM/day of ration B010 fed to 1000 lb steers.
[e]Ad lib fed prairie hay (11.5 and 9.7 lb) plus 2 lb of a 40% protein soybean meal supplement per 1000 lb steer daily.
[fg]Means within a trial with different superscripts differ statistically ($P<.05$).
[hi]Means within a trial with different superscripts differ statistically ($P<.10$).

Table 2. Feed intake and ruminal turnover.

Ration[a]	Number of animals	Ruminal turnover liquid
Maintenance (M)	4	3.04
1.33 x M	4	3.45
1.67 x M	4	3.95
2 x M	4	5.29

[a]Mulitples of 5.6 lb DM/day of an 84% rolled corn, 5% cottonseed hulls, 5% alfalfa, 5% soybean meal ration for 628 pound steers.

Level of roughage in the ration had a marked effect on liquid phase turnover rate (Table 3). Addition of 30 percent cottonseed hulls increased apparent liquid turnover rate greatly. In further study of roughage levels, three different rations-100 percent rolled corn grain, 100 percent chopped alfalfa hay and a mixture of 50 percent of each-were fed. Liquid turnover rate increased as some alfalfa was added but declined again when 100 percent alfalfa hay was fed. Although outflow (gallons per day) increased with each addition of alfalfa, rumen volume increased as well. This compensated to reduce rate of liquid turnover when expressed on a percent of liquid flowing out per hour. The changes in solid phase turnover tended to parallel those of the liquid phase.

Table 3. Roughage level and source.

Ration	Number of animals	Ruminal turnover, %/hr liquid	Solid
High concentrate[a]	4	5.7[a]	---
70% concentrate[a]	4	18.8[b]	---
High concentrate[b]	6	6.43[a]	4.38
50% concentrate, 50% alfalfa[b]	6	7.80[b]	5.91
Alfalfa[b]	6	6.31[a]	3.37
High concentrate[c]	10	5.3	4.5
High roughage[d]	4	5.2	2.2

[a]Fed 11.9 lb DM/day of 87 or 62% rolled corn, 5 or 30% cottonseed hulls, 5% soybean meal ration to 1000 lb steers.
[b]Fed at a rate of 1.5% of body weight to 1000 lb steers.
[c]Fed 13.5 lb DM/day of 91% rolled corn, 5% cottonseed hulls, 1% alfalfa, urea and minerals to 1100 lb steers.
[d]Fed 13.3 lb DM from prairie hay plus 1.8 lb of a 20 or 40% protein supplement per day to 1100 lb steers.

Table 4. Particle size and ruminal turnover rate.[a]

Screen size	Number of animals	Ruminal turnover liquid
1/8 inch	4	4.52
3/16 inch	4	6.54
5/16 inch	4	6.23
Whole	4	5.88

[a]Same ration as table 2.

Corn was ground through different screens to achieve various particle sizes (Table 4). No definite relationship between grinding of corn and rumen liquid turnover rate was detected.

Feed additives which increase ruminal turnover rate appear in general to increase efficiency of feed use during early portions of a finishing trial but depress digestibility. Additives which reduce ruminal turnover rate generally enhance digestibility but may depress intake. If protein supply limits performance at feedlot steer weights below 750 lb and energy availability limits efficiency of feed use at heavier weights, use of a stimulant early and a depressant later may prove useful.

Fermented, Ammoniated Whey - Its Energy and Protein Value

D. C. Weakley and F. N. Owens

Story in Brief

A rolled corn diet was supplemented with either urea, urea plus lactate (UL), soybean meal (SBM) or fermented ammoniated condensed whey (FACW), and fed to steers in a metabolism respiration calorimetry trial. Nitrogen digestibility (percent), N retention (g) and ruminal ammonia values for U, UL, SBM and FACW rations were 69.5, 73.9, 76.5, 71.4; 10.7, 8.3, 27.3, 12.9; and 30.6, 23.9, 13.9 and 27.5, respectively. Metabolizable energy values of the rations were 2.98, 3.02, 3.27 and 2.99. FACW (wet basis) was calculated to have a metabolizable energy value 51 percent the value of corn grain. Methane production and the acetate to propionate ration were not altered by additives.

Introduction

Nearly 15 million tons of whey are produced annually in the United States as a by product of the dairy industry. Although several processing techniques for whey have been suggested, the potential for its recycling in ruminant feeds has received relatively little attention. One recycling technique ferments the whey plus ammonia with a strain of bacteria to produce lactic acid and bacterial protein. This is condensed by evaporation to 55 percent dry matter. Commercially produced by Calor Agriculture Ltd, Okemos, MI, this product is called fermented ammoniated condensed whey (FACW). As a percent of the dry matter, FACW contains 44 percent crude protein, mostly as ammonium lactate and 80 percent lactate. It has been proposed that rations high in lactic acid tend to decrease ruminal production of methane which could reduce energy

Table 1. Ration composition, dry matter basis.

Item	Ration			
	U	UL	SBM	FACW
		%		
Corn, rolled	76.5	69.1	64.6	69.0
Cottonseed hulls	10.8	10.7	8.5	10.6
Soybean meal	0	0	17.0	0
Urea	2.7	2.9	0	0
Lactic acid	0	3.94	0	0
FACW	0	0	0	7.96
Alfalfa hay, ground	5.4	5.4	5.3	5.3
Limestone	3.96	3.93	3.74	3.89
Salt, trace mineralized	1.32	1.31	1.13	1.29
Vitamins A & D	.12	.12	.12	.12
Analysis				
Dry matter	85.22	83.24	85.94	84.40
N, % of DM	2.51	2.68	2.55	2.52

Table 2. Metabolism trial results.

Item	Ration			
	U	UL	SBM	FACW
Animal, no.	4	4	4	4
Dry matter				
Feed, kg DM	3.34[ab]	3.14[a]	3.87[b]	3.48[ab]
Feces, kg	.846	.777	.834	.939
Digestibility, %	74.0	75.0	78.6	72.6
Nitrogen				
Feed, g	83.6	83.9	98.7	87.8
Feces, g	24.7	21.5	23.3	24.5
Urine, g	48.2	54.1	48.1	50.4
Digestibility, %	69.6	73.9	76.5	71.4
N retention, g	10.7[a]	8.3[a]	27.3[b]	12.9[ab]
Ruminal NH_3-N, mg/dl	30.6[b]	23.9[ab]	13.9[a]	27.5[b]

[ab]Means within a trial with different superscripts differ statistically (P<.05).

Table 3. Calorimetry results.

	Ration			
	U	UL	SBM	FACW
Energy, % of consumed				
Feces	26.8	25.8	21.6	27.5
Urine	3.2	3.3	2.7	2.7
Methane	7.2	6.3	7.2	7.1
Heat	59.8	66.4	58.1	61.0

Table 4. Gas and VFA's.

Item	Ration			
	U	UL	SBM	FACW
Respiratory quotient	0.99[b]	0.89[a]	0.94[ab]	0.98[b]
VFA, molar ratio				
Acetate	56.7	60.9	53.8	51.2
Propionate	20.6	19.1	28.2	23.8
Butyrate	17.0	14.1	12.8	18.7
Isobutyrate	1.4	1.2	1.4	1.2
Isovalerate	1.0	1.0	0.7	0.8
Valerate	1.7	1.7	1.8	2.1
Total concentration, mM	102.0	112.3	99.2	105.9
C_2/C_3	3.18	3.73	2.52	2.44
Non-glucogenic	4.80	5.28	3.55	4.10

[ab]Means within a trial with different superscripts differ statistically (P<.05).

Table 5. Ration energy concentrations (kcal/g dry matter).

Item	Ration			
	U	UL	SBM	FACW
Gross	4.25	4.26	4.32	4.28
Digestible	3.16	3.16	3.39	3.10
Metabolizable (ME)	2.98	3.02	3.27	2.99

loss during ruminal fermentation. The purpose of this study was to evaluate energy and nitrogen availability of FACW and to also observe the effect of added lactate on ruminal methane production and ruminal acid levels.

Materials and Methods

Four 344 kg yearling steers were fed a rolled corn based ration (Table 1) with supplemental FACW, urea, UL or SBM. Urine and feces were collected the last five days of each 14 day period and steers were rotated among rations. Face masks were used for collection of respiratory gases for 12 hr beginning 1 hr after initiation of feeding the last day of each period. Oxygen consumption, and CO_2 and CH_4 production were monitored. On the final day of each period, rumen samples were obtained for analysis.

Results and Discussion

Dry matter and nitrogen digestibility tended to be the greatest for the steers fed the SBM supplemental ration followed by UL, U, and FACW supplementation (Table 2). Nitrogen retention was somewhat higher for SBM and FACW fed steers while ruminal ammonia values were lower for steers fed SBM than those fed U and FACW. This suggests that the ammonia from FAÇW is available in the rumen. As a percent of consumed energy, methane production for U, UL, SBM and FACW rations was 7.2, 6.3, 7.2, 7.1 (Table 3). No significant differences were detected in the digestible or metabolizable energy content of the rations. The respiratory quotient (CO_2/O_2) was lower for UL than U, SBM or FACW fed steers (Table 4). The acetate molar ration for FACW fed steers tended to be slightly lower than for the other rations. Based on ME (Table 5), FACW has an energy content of 1.41 kcal/g of material as fed. Using the mean of 1.41 kcal/g FACW and 2.76 kcal/g for corn grain at 15.5 percent moisture, the best estimate from this trial would be that FACW has 51 percent of the ME of corn grain. Calculated digestible and net energy values for FACW are also less than corn grain. No reduction in methane production was apparent. This refutes the idea that added lactate depresses methane production in the rumen so that high lactate feeds and silages would have slightly extra nutritional value.

Sila-bac Evaluation

R. A. Zinn, F. N. Owens, K. L. Mizwicki, A. B. Johnson and K. B. Poling

Story in Brief

The influence of Sila-bac silage inoculant on storability and digestibility of corn silage was evaluated using eight Charolais heifers. Wet weight and spoilage losses were slightly greater with treated silage. Digestibility of organic matter was 58.4 *vs* 56.9 and of fiber was 38.5 *vs* 35.3 percent for untreated and Sila-bac silage.

Materials and Methods

Corn silage used in this study (Pioneer Variety 3147) was harvested in the early dent stage on June 6, 1978, in Weslaco, Texas. Treatments consisted of a control or untreated silage and a Sila-bac inoculated silage. Sila-bac, a commercial silage additive marketed by Pioneer Hybrid International Inc., Des Moines, Iowa, was added to the chopped forage at the rate of 1 lb/ton of forage diluted with 9 lb of ground corn to aid distribution. For fermentation, chopped forage was placed in large, heavy duty plastic bags holding approximately 50 lb each. Seventy-one days later, the silage was transported to O.S.U. and stored frozen prior to feeding. Bags were weighed initially and at feeding to estimate wet weight loss. Compositions of silages are shown in Table 1.

Apparent digestibility of the silage was measured using eight Charolais heifers, averaging 800 lb. Animals were fed 6 lb of dry matter from their respective rations twice daily. Chromic oxide and a urea mineral supplement (Table 2) were incorporated into

Table 1. Composition of control and Sila-bac treated corn silage (DMB).

Item	Control	Sila-bac
	---------- % ----------	
DM	33.0	32.8
Ash	6.6	7.5
ADF	29.6	28.0
N	1.3	1.3

Table 2. Supplement composition[1].

Item	%
Urea, %	67.7
Trace mineralized salt, %	16.0
Dicalcium phosphate	16.2
Vitamin A and D	+

[1] Supplemented at rate of 1.6% of total ration dry matter.

Table 3. Weight loss and spoilage.

Item	Control	Sila-bac
	---------- % ----------	
Wet weight loss	0.98	2.59
Spoiled or moldy	2.76	3.96

Table 4. Apparent digestibility estimates for control vs Sila-bac treated corn silage.

Item	Control	Sila-bac
Digestibility	---------- % ----------	
Organic matter	58.4	56.9
Fiber	39.8	33.1
Nitrogen	40.0	35.8

the ration at the time of feeding. Following an initial 14-day standardization period during which all animals received the control silage ration, animals were placed on their experimental rations. During the course of the trial one heifer was removed due to illness. Test periods lasted 12 days, with feces being sampled the final five days. Heifers were then switched to opposite rations for collection. Silage and fecal samples were analyzed for dry matter, ash, acid detergent fiber and protein.

Results and Discussion

Although at ensiling the forage material appeared very acceptable, the fermented material contained mold in some areas. Poor air exclusion and temperatures over 100° F at harvest and during storage may have altered normal fermentation.

Loss of wet weight through fermentation and amount of spoiled material which could not be fed are presented in Table 3. Addition of Sila-bac did not reduce fermentation or spoilage losses in this trial. Digestibilities are shown in Table 4. The additives did not enhance digestibility as a previous laboratory study (Rust *et al.*, 1978) predicted. All digestibilities appeared quite low, possibly due to high temperatures of fermentation and storage. Although the inoculant may be useful for higher moisture, out-of-season or difficult-to-ensile crops, as others have indicated, results from this trial showed no benefit from the inoculant.

Literature Cited

Rust, S. R., F. N. Owens, A. B. Johnson, B. J. Shockey and K. B. Poling. 1978. Okla. Agr. Exper. Sta. Res. Rep. MP-103:146.

Sludge Evaluation

R. A. Zinn, F. N. Owens and R. P. Lake

Story in Brief

Metabolism experiments were conducted with four mature steers in a crossover design experiment, to evaluate the digestibility of sludge, the residue of a process which recycles cattle waste to generate methane. Sludge was fed at 15 or 30 percent ration dry matter. At either level, animals were very reluctant to consume feed. Apparent digestibility of sludge dry matter, organic matter, acid detergent fiber and nitrogen was 30, 45, 17 and 25 percent, respectively. In another study, the digestibility of sludge in the rumen was estimated. This technique estimated sludge organic matter and fiber digestibilities at 38 and 41 percent.

Introduction

As conventional roughage supplies become increasingly scarce and costly, the search for alternative fiber sources increases in importance. One potential option is the fibrous residue from generation of methane gas. This sludge is the by-product of an anaerobic fermentation process for which feedlot waste is the starting ingredient. Sludge is made up of two components: 1) screenings, the residue obtained as the waste material is sifted through a series of sieves prior to being fermented to methane and 2) centrifugate, the solids, principally microbial, obtained from high speed centrifugation of the fermented liquor.

Materials and Methods

Sludge used in the present study was obtained from a methane generation plant at Guymon, Oklahoma. Nutrient digestibility of the material was estimated following two procedures: 1) by feeding to steers and 2) by suspending the material in the rumen for digestion. Four 900 lb steers were used in a crossover design experiment in which sludge was fed at 15 or 30 percent of total ration dry matter. Ingredient composition of the experimental diets is shown in Table 1. Steers were fed 5 lb of dry matter from their respective diets twice daily. Test periods lasted 15 days with fecal sampling the final five days.

For the ruminal digestibility study, sludge disappearance was compared to that of corn silage. Fresh samples (as fed basis) of sludge or corn silage were placed in dacron bags (approximately 100 mesh) and incubated simultaneously in the rumen of a mature fistulated steer maintained on prairie hay. Bags containing samples of each material were removed at 5 hr intervals for 30 hours. Sludge digestibility was estimated at that point when 70 percent of the corn silage dry matter had disappeared. All samples were analyzed for dry matter, ash, acid detergent fiber and nitrogen.

Results and Discussion

The composition of methane generator sludge in comparison to corn silage and alfalfa hay is shown in Table 2. The sludge material has a relatively high ash and fiber content. Animal digestibility of dry matter, organic matter, acid detergent fiber and protein was 30, 45, 17 and 25 percent respectively. Corresponding estimates for ruminal digestibility of organic matter and acid detergent fiber were 38 and 41 percent (Table 3).

Table 1. Ingredient composition of experimental diets (DMB).

Item	Diets 1	Diets 2
	---- % ----	
Sludge	15	30
Cracked corn	80	65
Urea supplement	5	5

Table 2. Composition of methane generator sludge, alfalfa hay and corn silage.

Item	Dry Matter	Ash	Fiber	Protein
	%	---- % of Dry matter ----		
Sludge	35.7	24.0	59.3	14.2
Corn silage	33.0	6.6	24.4	8.1
Alfalfa hay	90.0	8.9	26.6	17.9

Table 3. Sludge nutrient digestibility.

Item	Dry matter	Organic matter	Fiber
	---- % ----		
Animal[a]	30 ± 7.5	45 ± 8.3	17 ± 11.4
Ruminal	---	38	41

[a]Mean ± standard error of estimate.

Although the sludge no longer retains a characteristic fecal odor, acceptability of the material by animals was very poor. After nearly one month adaptation with *ad libitum* access to feed, maximum intake of a diet containing 15 percent of its dry matter as sludge by one steer was less than 9 lb per day. In the light of the high ash and fiber content, low digestibility and poor animal acceptability, it appears the methane generator sludge currently is not suitable as an alternative roughage source for ruminants. If intake problems were solved, the material might prove useful at a low level for maintaining cows.

Cement Kiln Dust Trials

R. A. Zinn, D. R. Gill,
F. N. Owens and K. B. Poling

Story in Brief

The influence of kiln dust on animal performance and nutrient availability was evaluated. Kiln dust was found ineffective in enhancing performance of finishing cattle or laboratory rats. While kiln dust supplementation may improve fiber digestibility and retention of nitrogen and calcium, higher levels may reduce feed intake and increase liver abscesses.

Introduction

Cattle feeders in Georgia first supplemented cattle feed with the waste kiln dust from cement manufacturing. Wheeler and Oltjen (1977) substituted 3.5 percent kiln dust for the protein and mineral supplement in a 50 percent roughage ration for finishing steers. They obtained increased rates (28 percent) and efficiencies of gain (21 percent) from addition of 3.5 percent kiln dust.

Similar results were obtained in a second study with steers and lambs (Wheeler and Oltjen, 1979). In the latter study, steers receiving kiln dust with an 8.4 percent crude protein ration gained 67 percent faster while with a 12.3 percent crude protein ration, gains were increased by 25 percent. Similarly, lambs receiving an 8.4 percent protein diet supplemented with kiln dust gained 352 percent faster while supplementation of a 13.6 percent crude protein ration increased gain by 20 percent. Other work with kiln dust has not looked so promising.

Some studies have even indicated a possible negative response (Personal communications - G. M. Ward, Colorado; W. B. Anthony, Alabama). Certainly the response could vary with source and type of kiln dust. The objective of this research was to determine the influence of various sources and types of supplemental cement kiln dust on (1) growth and performance of nonruminants (rats) and ruminants (steers) and (2) nutrient digestibility of high concentrate and high forage diets.

Materials and Methods

Experiment 1

Seventy-five 635 lb steers were used in a feedlot trial. Treatments consisted of two protein levels, 9.3 and 11.5 percent, and four levels of added cement kiln dust (0, 0.87, 1.75; 3.48 percent). Ingredient composition of experimental diets as well as allocation of animals to treatments is shown in Table 1. After 41 days, the low protein and 3.48 percent kiln dust treatments were discontinued because of reduced rates of gain.

Experiment 2

Three laboratory rat growth trials were conducted. In the first trial, 1 percent added cement dust from three locations (Pryor, Oklahoma, Ada, Oklahoma and Rome, Georgia) were compared to a 0 control and an ashed salt mix for ability to stimulate growth and performance. In addition, four different stages and byproducts of cement manufacturing (Baghouse, Buell, Clinker or cement) obtained from Pryor, Oklahoma, were compared. Rations contained 80 percent ground corn, 11 percent casein, 3.8 percent cellulose, 0.24 percent salt, methionine and choline chloride.

In the second trial, four different kiln dust samples obtained from Rome, Georgia were added at the 1 percent level to a low protein ration consisting of 31 percent ground

Table 1. Experimental diets and animal allocations[a].

	Protein levels					
Item	9.3%	9.3%	11.5%	11.5%	11.5%	11.5%
Steers, no.	13	12	12	13	12	13
Kiln dust	0	3.34	0	0.87	1.75	3.48
Cracked corn	79.2	75.4	73.7	73.5	72.4	70.2
Cottonseed hulls	12.7	13.0	12.7	12.7	12.7	12.7
Soybean meal	.8	1.5	6.4	6.5	6.7	7.1
Dical	.30	.33	.16	.16	.17	.19
Lime	.73	0	.75	0	0	0

[a]Alfalfa hay (1.5%), salt (0.3%), Monensin (30 g/ton) and vitamin A were added to all rations.

Table 2. Ingredient composition (digestion trials).

Ingredient	Concentrate[a]	Roughage[b]
	%	
Corn, cracked	60.9	- - - -
Corn silage	- - - -	97.4
Cottonseed hulls	13.6	- - - -
Soybean meal	9.7	- - - -
Molasses	6.9	- - - -
Alfalfa hay, ground	5.8	- - - -
Salt, mineralized	.5	0.25
Limestone	.5	- - - -
Dicalcium phosphate	.5	0.26
Urea	.1	1.05
Water	2.0	- - - -

[a]To form the test ration, 3.5% kiln dust was added.

[b]To form the test ration, 1% kiln dust from either Oklahoma Cement or Martin Marietta Cement Company were added.

corn, 6 percent casein, 4.5 percent minerals, 4 percent corn oil, 4 percent cellulose, 0.25 percent salt, methionine and choline chloride.

In the third trial, influence of cellulose on response to supplemental cement dust was investigated. Rations consisted of 93 or 54 percent ground corn, 4 or 40 percent cellulose, 2 percent corn oil, 1 percent kiln dust and trace mineralized salt.

Experiment 3

Two metabolism trials were conducted to investigate influence of cement dust on nutrient utilization. In the first trial, four 650 lb steers were used in switchback design experiment to determine influence of cement dust on digestibility of a high concentrate diet. Ingredient composition of experimental diet is shown in Table 2. Kiln dust was added at 3.5 percent to form the test ration.

In the second trial, eight 665 lb steers were used in a completely random design to determine the influence of 1 percent added cement kiln dust on digestibility of an all corn silage ration. Steers were limit fed 9 lb of corn silage dry matter per day. Ingredient composition of experimental diets is shown in Table 2. Steers were allowed 14 days adaptation to silage treatments followed by five-day fecal collection period.

Results and Discussion

Experiment 1

The influence of cement kiln dust on cattle performance, fecal pH and fecal starch is shown in Table 3. Added cement kiln dust at the higher protein level tended to depress feed intake and rate of gain with little effect on efficiency of feed use. Added dust did not improve performance at the low protein level, but higher kiln dust supplementation appeared to decrease fecal starch and increase fecal pH. Carcass characteristics were similar for all treatments; however, kidney-heart-pelvic fat appeared to decrease and liver abscess scores to increase markedly with added kiln dust.

Experiment 2

The influence of source and type of cement dust on rat growth and performance is shown in Table 4. Differences between treatments were small although the first three weeks, added dust increased gains slightly. A comparison of four different Rome, Georgia samples of cement kiln dust on rat growth and feed efficiency is shown in Table 5. Again treatment differences were small with no advantage for added kiln dust. Performance of rats fed high and low cellulose diets with and without added kiln dust is shown in Table 6. With both the high and low cellulose diets, added kiln dust depressed daily gain and feed efficiency.

Table 3. Influence of cement kiln dust of feedlot steers.

Protein	9.3		11.5			
Kiln dust	0	3.44	0	0.87	1.75	3.48
Ca	.45	1.11	.45	.40	.64	1.11
Steers, no.	13	12	12	13	12	13
Initial weight	631	633	636	635	644	633
Daily gain, lb						
0-41	3.64[a]	3.66[a]	4.77[c]	4.87[c]	4.40[bc]	3.90[ab]
41-134	---	---	2.83	3.03	3.14	---
0-134	---	---	3.48	3.36	3.33	---
Daily feed, lb dry matter						
0-41	16.4	17.7	20.0	19.2	17.6	16.3
41-134	---	---	22.2	22.5	22.4	---
0-134	---	---	21.5	21.5	20.9	---
Feed/gain						
0-41	4.50	4.83	4.19	3.95	4.00	4.17
41-134	---	---	7.84	7.44	7.16	---
0-134	---	---	6.20	6.41	6.30	---
NE_g						
0-41	1.49	1.43	1.57	1.65	1.64	1.58
0-134	---	---	1.26	1.20	1.20	---
Fecal pH, day 41	5.09[a]	5.78[bc]	5.42[ab]	5.16[a]	6.38[d]	6.15[cd]
Fecal starch, day 41	23.9	23.4	24.9	23.4	14.1	15.5
KHP fat, %	---	---	3.00	2.84	2.83	---
Liver abscesses, %	---	---	8.3	23.1	41.7	53.8
Abscess severity	---	---	1.0	1.7	1.6	2.1

[abcd]Mean values in the same row not followed by same superscript differs significantly ($P<.05$).

Table 4. Source and type of cement dust and rat growth (Trial 1).

Source	Level %	Daily gain, G 21 days	Daily gain, G 34 days	Gain/feed 17 days
None	0	4.02[a]	4.81	.40
Pryor				
Baghouse	1.0	3.92	- - - -	.40
Buell	1.0	3.86	- - - -	.39
Clinker	1.0	3.82	- - - -	.37
Cement	1.0	3.99	- - - -	.36
Ada dust	1.0	3.86	- - - -	.39
Georgia dust	0.5	4.11	4.91	.39
	1.0	4.16	4.86	.38
Salt mix	1.0	4.04	- - - -	.36
(ashed)	1.6	3.98	- - - -	.39

[a]Three rats per treatment.

Table 5. Comparison of four types of georgia cement kiln dust (Trial 2).

Source	%	Daily gain, grams 13 days	Gain/feed 13 days
None	0	6.09[a]	.298
Georgia #1	1.0	6.08	.272
Georgia "hot"	1.0	5.90	.275
Georgia #3	1.0	5.77	.275
Georgia #4	1.0	6.10	.277

[a]Four rats per treatment.

Table 6. Cement kiln dust and performance of rats (Trial 3).

Treatment: Cellulose	Treatment: Dust	Daily gain, grams 12 days	Gain/feed 12 days
–	–	4.66[a]	.102
–	+	4.01	.090
+	–	1.73	.031
+	+	.13	.002

[a]Seven rats per treatment.

Table 7. Digestibilities and retentions (by steers).

Item	Ration: Control	Ration: Dust
Intake, lb	11.7	10.5
Digestibility, %		
Dry matter	74.1	77.3
Organic matter	75.1	79.9
Protein	66.8	71.4
Starch	91.2	96.8
Calcium	20.3	35.5
Retention, g/day		
Nitrogen	24.8[a]	33.1[b]
Calcium	6.4[a]	24.8[b]

[ab]Treatment in the same row not having similar superscripts differ significantly ($P<.05$).

Table 8. Cement kiln dust and digestibility of corn silage (Digestion Trial 2).

Item	Treatment		
	Control	Martin Marietta	Oklahoma cement
Digestibility, %			
Dry matter	68.2	69.5	69.4
Organic matter	73.4	73.9	73.3
Acid detergent fiber	46.2^{a}	50.9^{b}	53.2^{b}
Nitrogen	52.4	56.7	56.6

^{ab}Treatment means in the same row with different superscripts differ statistically ($P<.06$).

Experiment 3

The influence of cement kiln dust on feed digestibility and nutrient metabolism was evaluated in two trials. The 80 percent concentrate ration provided 11.3 percent protein and 0.63 or 1.49 percent calcium. Supplemented kiln dust caused a slight depression in dry matter intake (Table 7). While differences were small, apparent digestibility of all constituents tended to be greater for the kiln dust supplemented ration. Nitrogen and calcium retention were increased markedly when steers were fed the cement dust.

In the second trial, digestibility of nutrients from the corn silage ration was increased slightly (Table 8). Protein digestibility was improved by 9 percent and fiber digestibility by 13 percent when corn silage was supplemented with 1 percent cement kiln dust.

Results of the trials conducted to date are inconclusive; occasional benefits noted have been small. While producing no stimulating effects in terms of animal performance, our results indicate that kiln dust may have some potential for improving digestibility of fiber in high fiber rations. The high calcium digestion and retention also indicate that cement dust is a usable supplemental source of calcium. Potential problems, such as reduced feed intake, increased liver abscess incidence and contamination with fluorine and heavy metals may limit use of kiln dust. It is as yet unapproved as a feed additive.

Literature Cited

Wheeler, W. E. and R. R. Oltjen. 1977. USDA, ARS-NE-88.

Wheeler, W. E. and R. R. Oltjen. 1979. J. Anim. Sci. (In Press).

Lyophilized Rumen Fluid for Use in In Vitro Dry Matter Disappearance Studies with Grain

J. Kapp, R. L. Hintz and D. G. Wagner

Story in Brief

The effect of lyophilization on rumen fluid and its subsequent use in *in vitro* dry matter disappearance (IVDMD) procedures with corn grain was investigated. The rumen fluid, collected via rumen cannula from a mature Holstein steer, was utilized either a) *fresh* as in standard IVDMD procedures, b) *prefrozen rapidly* prior to lyophilization (PR), or c) *prefrozen slowly* (PS) prior to lyophilization. The lyophilized rumen fluid was then stored either frozen (F) or at room temperature (S) preceding its use in the IVDMD evaluation.

In three sequential 24-hr *in vitro* evaluations, no significant differences could be detected in the *in vitro* digestibility of corn between the fresh rumen fluid or any of the lyophilized rumen fluid treatments, PR-F, PR-S, PS-F or PS-S. The variation within each of the treatments, however, was relatively large. This study suggests the potential efficacy of lyophilized rumen fluid for use in IVDMD evaluations of grains and supports the suggestion that continued work with the lyophilized rumen fluid, including potential uses for forages, is warranted.

Introduction

The use of IVDMD procedures for predicting the nutritive value of grains and forages is widespread. One of the main advantages of the *in vitro* technique is the ability to study microbial digestion away from the control and influence of the host animal. This technique yields a rather accurate estimate of the digestibility of different feedstuffs. Such information is useful in comparing feeds, grains or forages. Moreover, many states, either via land grant universities, USDA extension services, or private laboratories, offer forage and feed evaluation services to producers. *In vitro* digestibility is often one of the major criteria evaluated as an indicator of nutritive value.

Previous research clearly demonstrates the variation of the IVDMD procedure between as well as within laboratories. A major source of this variability arises from differences in the rumen fluid itself, due to the diet of the host animal, animal differences or differences in processing or handling of the fluid. Most commonly, each laboratory or testing station will maintain a donor animal and routinely remove

Table 1. Composition of artificial saliva-buffer solution.

Ingredient	Gm/liter of distilled H_2O
$NaHCO_3$	9.80
Na_2HPO_4	3.69
KCl	0.57
NaCl	0.47
$MgSO_47H_2O$	0.12
$CaCl_2$	0.04
Urea	0.91

inoculum as needed. This is a laborious, objectionable practice and tends to be expensive due to maintenance of the donor animal. If the inoculum used in IVDMD procedures could be standardized, then a large amount of the variability of the technique might be eliminated. Similarly, if a product could be developed that would eliminate the need for a donor animal, then perhaps the cost of the evaluation could be reduced and simplified for many laboratories.

Lyophilization, or freeze-drying, has been employed by microbiologists to maintain bacterial cultures with varying degrees of success. In an attempt to standardize the IVDMD procedure, this research was conducted to investigate the effectiveness of a lyophilized rumen fluid product for use in these types of studies.

Experimental Procedure

Five separate samples of approximately 500 ml of whole rumen fluid were removed directly from the rumen of a mature Holstein steer fed 10 lb per day of a 84 percent corn, 16 percent supplement cottonseed hull ration. Water and feed were withheld eight hr prior to sampling to avoid dilution of the microbial population.

Each sample was strained through six layers of cheese-cloth and continuously flooded with CO_2 to promote anaerobic conditions. Two-hundred ml of strained fluid were retained from each of the five samples; one was used fresh. The four remaining samples were then placed in 600 ml lyophilizer flasks, flooded with CO_2 and sealed with parafilm.

Two of these samples were frozen rapidly (PR) by spinning the flasks in dry ice and acetone, and two samples were frozen slowly (PS) by placing the flasks in a conventional freezer at −10 C. Eighty ml of the fresh rumen fluid sample were mixed with 220 ml of artifical saliva or buffer (composition presented in Table 1). Thirty ml of the rumen fluid buffer mixture was then incubated as per standard IVDMD procedure with approximately .40 g of corn grain ground through a 20-mesh screen in a laboratory Wiley mill. Dry matter disappearance was determined by differences after 24 hr of incubation.

When frozen, the remaining four samples were lyophilized to completion on a Virtis 10-100V lyophilizer. After lyophilization, the rumen fluid appeared as a dry, fine powder. One sample of each of the two freezing treatments were then stored either in the freezer (F) or at room temperature (S).

After 24 hours, all lyophilized rumen fluid samples (PR-F, PR-S, PS-F, PS-S) were reconstituted to their original volume with distilled water, which had been prewarmed to 39 C and flooded with CO_2 for 10 minutes. Eighty ml of each reconstituted sample were mixed with 220 ml of artificial saliva and for each sample the same inoculation and incubation procedure as used for the fresh fluid was carried out. A second and third replication of this experiment were conducted on successive weeks.

Table 2. Twenty-four hour IVDMD of ground corn using fresh and lyophilized rumen fluid.

Treatment	% DMD Week 1	Week 2	Week 3
Fresh	65.0[4]	47.4[3]	70.3[1]
PR-F	77.7[1]	38.6[4]	67.7[2]
PR-S	73.9[3]	48.1[2]	58.0[4]
PS-F	63.2[5]	14.3[5]	66.6[3]
PS-S	75.2[2]	55.4[1]	44.4[5]

[1,2,3,4,5]Indicates rank within weeks.

Results and Discussion

Table 2 shows the percent DMD for the fresh and lyophilized rumen fluids. No significant differences (P>.1) due to treatment of the fluid were observed; however, a significant effect due to week was observed. The within treatment variations for all the fluids were large, and may reflect the innate variation within the IVDMD procedure itself. The relative rank of efficiency of DMD for each treatment varied between weeks, suggesting a treatment by week interaction. Because of the vast practical benefit that a storable rumen inoculum product for IVDMD use would afford, these data confirm the efficacy of such a product and suggest that further investigation into the accuracy and repeatability of the lyophilization process is warranted.

Bovine Boots - A New Research Tool

F. P. Horn and G. E. Miller

Story in Brief

To meet the need for precise determinations of forage intake by grazing livestock, an Animal Weight Telemetry System has been developed. Four "boots" containing electronic load cells generate analog signals which are summed, converted to a digital signal and transmitted to a laboratory receiver for interpretation. Minor changes in body weight, coupled with observation of grazing behavior, permit direct and precise measurement of intake continuously or at selected intervals.

Introduction

Two major determinants of forage feeding value are digestibility and intake potential. Evaluation of forages as livestock feed under grazing conditions poses special problems to researchers because of the tendency of grazing animals to "select" plants or parts of plants. Furthermore, livestock eat different amounts of forage when they graze from when they are fed in confinement in pens or stalls. Precise measurement of intake has heretofore been impossible. Expensive and inaccurate estimates of intake have often been assigned to forages for purposes of forage-quality ranking, feed formulation and animal performance prediction. The "bovine boots" will allow development of more reliable feeding programs and promote more efficient and economical livestock nutrition research.

Materials and Methods

A beef steer has been outfitted with boots and accessories needed to determine the pressure exerted on the ground because of its body weight.

The basic components of the "Bovine boots" telemetry system include (1) a laboratory-housed base facility to activate the field equipment, receive data and condition those data, (2) backpack-housed signal conditioning and transmitting equipment, (3) harnesses to support electrical cables on the animal and (4) boots/

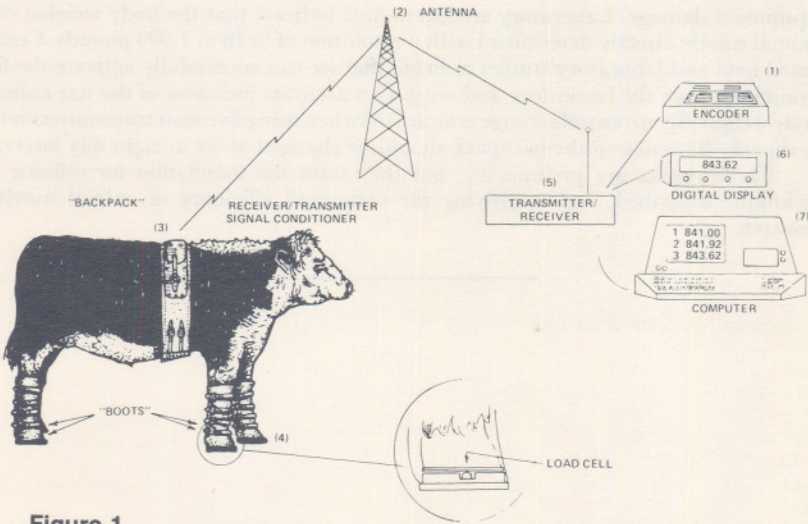

Figure 1.

transducers to convert the pressure resulting from the animal's body weight into a signal suitable for transmission. The relationship between these components of the system is illustrated in Figure 1.

The system currently under study at the Southwestern Livestock and Forage Research Station, has the capacity to monitor 36 animals in rapid sequence or a single animal constantly, as desired. The weighing is accomplished via the following sequence of events:

- The operator indicates the animal selected by keying in animal ID number on encoder.
- The encoder transmits a radio activating signal via the base transmitter to the backpack receiver/transmitter.
- Independent analog signals from four transducers (one in each boot) move from the boots to the backpack, then are summed and converted to binary-digital format for transmission.
- The backpack transmitter sends the digital signal to the base receiver.
- The operator reads the animal's body weight on a digital readout (optionally data may be directed to a "mini-computer" in standard RS232 data format).

The system, therefore, allows one operator, through use of the encoder and digital readout, to instantaneously determine the precise body weight of the grazing animal. In order to conduct research on several animals concurrently, the operator would sequentially determine body weights by entering a series of animal identification numbers into the encoder. The radio equipment transmits in the FM, operating in the 144 to 175 MH_z band; hence, range is determined by "line-of-site" as well as backpack transmitter output.

Results and Discussion

Field studies over the past 12 months have only included tests of the boots (with transducers), harnesses and backpack. Equipment has been developed which under "normal" conditions will function properly with a minimum of maintenance and equipment damage. Laboratory studies to date indicate that the body weights of an animal can be directly determined with a resolution of ½ lb in 1,000 pounds. Coordinated field and laboratory studies indicate that we can successfully activate the field equipment from the laboratory and receive an accurate indicator of the test animal's body weight. Six to ten miles range is indicated when using five watt transmitters on the backpack. Batteries on the backpack should be changed at six to eight day intervals.

These results are preliminary, but they form the foundation for refining the technique described, and improving the value and efficiency of animal nutrition research.

Effect of Preweaning Milk Level and Biological Type on Postweaning Feedlot Performance and Carcass Traits

G. L Crosthwait, R. D. Wyatt,
L. E. Walters and Robert Totusek

Story in Brief

The effect of two levels of preweaning milk intake on postweaning feedlot performance and carcass merit by calves of two growth potentials was determined. This was accomplished by breeding Hereford cows to Angus bulls and Holstein cows to Charolais bulls. This was followed by reciprocal cross-fostering, whereby, calves of each breed combination were exposed to a low (Hereford) or high (Holstein) level of milk. Calves that had been raised to weaning on range were group fed while calves that had been reared in drylot were individually fed during the feedlot finishing period. Calves were fed to an estimated low choice grade.

The high level of milk consumption resulted in an additional 103 and 104 lb of weaned weight among Angus x Hereford and Charolais x Holstein calves, respectively.

Calves which received the higher preweaning milk levels tended to be heavier at slaughter, produced heavier carcasses and generally required fewer days to reach slaughter grade.

Introduction

Previous research has shown that weaning weights can be improved by increasing the milk production of beef cows. In recent years, there has been considerable interest in the infusion of dairy blood into beef herds as a means of rapidly increasing the milk yield of cows and thus increasing weights. However, heavier weaning weights produced increasing preweaning milk consumption will probably influence both the feedlot performance and carcass merit of calves because of either the higher nutrition levels (milk) or influence of dairy breeding. The purpose of this study was to compare the effects of two levels of preweaning milk intake on the postweaning feedlot performance and carcass merit of calves of two growth potentials.

Materials and Methods

Feedlot performance and carcass characteristics of calves to two growth potentials exposed to two levels of milk intake was determined. A system was devised whereby calves of similar breeding could be exposed to a low (Hereford) and high (Holstein) level of milk consumption during the preweaning interval. This was accomplished by breeding Hereford cows to Angus bulls and Holstein cows to Charolais bulls followed by reciprocal cross-fostering of about one-half of the calves at birth. Thus, within each

In cooperation with USDA, Science and Education Administration, Southern Region.

calf breed (Angus x Hereford and Charolais x Holstein) one group was the recipient of a low level of milk (10 to 11 lb/day) while another group received a high milk level (21 to 24 lb/day).

Cows and calves were maintained either on tallgrass native range or confined in drylot from birth to weaning. Cows received a post-calving winter supplement level calculated to allow a 20 percent winter weight loss including weight loss at calving. Supplement levels were based on earlier work on cow size and milk production levels at this station. Calves were born in December, January and February and weaned at 240 ± 7 days of age. Drylot calves were creep-fed while range calves received only grazed forage.

Parturition was induced in some cows by administration of 40 mg dexamethazone (Axium) within 10 days of their projected calving date to allow scheduling of the cross-fostering program. Calves were grafted onto foster dams within 12 hr following birth.

At weaning, calves were fasted for six hr, weighed, photographed and vaccinated for blackleg, parainfluenza-3 and IBR. Calves were placed directly into the feedlot at weaning.

Skeletal size was estimated from 2x2 slides taken with each calf behind a grid at weaning and prior to slaughter. Height was defined as the distance from the hip (tuber coxae) to the floor, length defined as the horizontal distance from the point of the shoulder (dorsal anterior humerus) to the hip. The hip and point of shoulder were marked with contrasting chalk prior to photographing to facilitate more accurate measurement.

Calves from drylot cows were individually-fed *ad libitum* in single pens with a covered feeding area. Calves from range cows were group-fed *ad libitum* in a barn with a covered feeding area and an outside loafing area.

Group-fed calves received a 75 percent concentrate ration consisting of the following percentages: gound corn, 60.2, cottonseed hulls, 15.0; ground alfalfa, 10.0; cottonseed meal, 8.0; molasses, 5.0; urea, 1.0; salt, 0.3; minerals and vitamin A.

Individually fed calves were fed a 92 percent concentrate ration consisting of the following percentages: whole corn, 87.0, cottonseed hulls, 5.0; and a pelleted supplement containing cottonseed meal, 3.5; soybean meal, 50.0; urea, 10.0; wheat mids, 3.5; salt; Vitamin A; minerals and chlortetrocycline.

Each calf was fed to an estimated quality grade of low choice based on visual estimates of apparent fat thickness. Final weights and photographs were taken after a 12 hr fast.

Group-fed calves were slaughtered in a commercial packing plant and chilled for 72 hr before quality grade, marbling score, maturity, conformation score, and kidney, heart and pelvic (KHP) fat were estimated by a USDA grader. Individually-fed calves were slaughtered at the Oklahoma State University Meat Laboratory and were evaluated in the carcass by a staff member. Rib eye area (REA) and backfat thickness were measured from a tracing at the 12th-13th rib separation on each carcass. Carcass grades were based on the Official U.S. Standards for Grades of Carcass Beef (1973).

Results and Discussion

Feedlot Performance

Feedlot performance of group-fed and individually-fed calves is summarized in Tables 1 and 2, respectively. Initial weight (weaning weight) increased among both group and individually-fed calves as the preweaning milk intake was increased. Charolais x Holstein calves were heavier than Angus x Hereford calves receiving a similar milk level. Heavier initial weights were a reflection of higher preweaning milk

Table 1. Effect of preweaning milk level and breed on feedlot performance of group-fed calves.

	Angus x Hereford		Charolais x Holstein	
	Low	High	Low	High
Initial wt, lb	497	602	551	662
Slaughter wt, lb	848	894	1226	1244
Days fed	152	136	289	250
Daily gain, lb	2.29	2.14	2.39	2.47
Feed conversion, (lb feed/lb gain)	7.93	9.14	8.79	10.70
Skeletal size				
Initial height, in	38.5	38.7	41.3	43.7
Initial length, in	27.0	27.3	28.0	31.5
Slaughter height, in	42.0	43.1	50.2	48.4
Slaughter length, in	32.0	32.5	36.6	38.6

Table 2. Effect of preweaning milk level and breed on feedlot performance of individually-fed calves.

	Angus x Hereford		Charolais x Holstein	
	Low	High	Low	High
Initial wt, lb	477	577	525	632
Slaughter wt, lb	877	907	1262	1323
Days fed	158	139	2.60	2.62
Daily gain, lb	2.58	2.39	2.60	2.62
Feed conversion (lb feed/lb gain)	6.79	7.14	8.61	8.80
Skeletal size.				
Initial height, in	38.3	40.9	42.3	43.3
Initial length, in	24.6	28.3	28.2	31.2
Slaughter height, in	43.1	44.3	50.5	48.2
Slaughter length, in	32.2	34.3	36.4	36.8

intakes and larger birth weights associated with the larger mature size of the Charolais x Holstein calves.

Slaughter weights tended to be heavier among calves receiving high preweaning milk levels. Angus x Hereford calves receiving the high preweaning milk level averaged 38 lb heavier at slaughter than those receiving the low milk level.

Charolais x Holstein calves receiving the high preweaning milk level averaged 39 lb heavier at slaughter than their low milk level counterparts. Charolais x Holstein calves averaged 382 lb heavier at slaughter than Angus x Herefords.

Angus x Hereford calves which received the high preweaning milk level tended to show lower rates of average daily gain than those which received the low milk level. This trend was reversed among Charolais x Holstein calves.

With the exception of individually fed Charolais x Holstein calves, those which received the high preweaning milk level required fewer days to reach slaughter grade.

Feed efficiency was affected among calves of both breed combinations with those on the high milk level having poorer feed efficiencies in both group-fed and individually-fed management systems.

Table 3. Effect of preweaning milk level and breed on carcass traits of group-fed calves.

Breed	Angus x Hereford		Charolais x Holstein	
Milk level	Low	High	Low	High
Item				
Hot carcass wt, lb	537	584	761	807
Ribeye area, in^2	10.1	10.2	12.9	13.7
Fat thickness, in	.79	.90	.60	.62
KHP fat[a]	3.29	3.44	2.72	3.58
Cutability, %	47.8	45.7	49.3	48.5
Conformation score[b]	8.25	8.75	7.68	7.67
Marbling score[c]	12.0	10.9	12.9	13.0
Carcass grade[b]	7.1	6.3	7.4	7.6

[a]Kidney, heart and pelvic fat.
[b]6=high good, 7=low choice, 8=overage choice.
[c]10=slight-, 11=slight, 12=slight +, 13=small-.

Table 4. Effect of preweaning milk level and breed on carcass traits of individually-fed calves.

	Angus x Hereford		Charolais x Holstein	
	Low	High	Low	High
Hot carcass wt, lb	538	559	801	851
Ribeye area, in^2	10.3	10.5	12.10	11.3
Fat thickness	.67	.66	.51	.72
KHP fat[a]	2.87	3.03	2.67	3.50
Cutability, %	48.8	48.8	48.9	46.4
Conformation score[b]	8.4	8.3	7.7	7.7
Marbling score[c]	10.1	13.7	11.7	13.5
Carcass grade[b]	6.4	7.5	6.6	6.8

[a]Kidney, heart and pelvic fat.
[b]6=high good, 7=low choice, 8=overage choice.
[c]10=slight-, 11=slight, 12=slight +, 13=small-.

Skeletal measurements indicate that calves receiving the high preweaning milk levels were both longer and taller than their counterparts of the similar breeding that received the low milk level.

Carcass Characteristics

Carcass characteristics of group-fed and individually-fed calves are summarized in Tables 3 and 4, respectively. Carcasses from Charolais x Holstein calves were heavier in all cases than those from Angus x Herefords.

Calves which received the high preweaning milk level produced carcasses which averaged 41 lb heavier than those which received the low milk level.

Preweaning milk level had little affect on rib eye area among calves of either breed combination.

Evidence of external fat thickness was one of the criteria used to estimate carcass grade in the live animal and therefore determine the time of slaughter. Some control was thus exercised over fat thickness in the carcass. Group-fed Charolais x Holstein calves tended to have less fat thickness over the rib than Angus x Hereford calves. This trend was not evident among individually-fed calves.

Group-fed calves which received the low preweaning milk level tended to produce carcasses with higher (1.5 percent) cutability. This trend was not evident among individually-fed calves.

Individually-fed calves which received the high preweaning milk level had higher marbling scores than those receiving the low milk level. A trend was not evident among group-fed calves.

Quality grade was not consistently influenced by preweaning milk level among calves of either breed combination.

Characteristics of Forage-Fed *vs* Grain-Fed Slaughter Cattle

Jim Williams, D. G. Wagner, L. E. Walters, J. J. Guenther, G. H. Horn and George Waller

Story in Brief

Thirty Brangus X Hereford-Angus crossbred steers (avg. 348.4 kg), approximately 13 months of age, were randomly assigned to three treatments: (1) 90 percent concentrate finishing ration for 161 days, (2) sorghum sudan and wheat pasture for 48 days, followed by the 90 percent concentrate finishing ration for 113 days, and (3) sorghum sudan and wheat pasture (190 days) until slaughter. Performance, carcass traits and chemical composition of the soft tissue were determined. Final slaughter weight and average daily gain (ADG) were lower for group 3 (928 and .83 lb) than for groups 1 (1075 and 1.96 lb) and 2 (1051 and 1.74 lb). Carcass traits, with the exception of percent of kidney, heart and pelvic fat (KHP), were similar for groups 1 and 2 and considerably higher than for group 3, except for rib eye area (REA). Animals in groups 1 and 2 graded 70 percent choice, 30 percent high good *vs* 60 percent standard, 40 percent good for those in group 3. Soft tissue in the carcass was significantly higher ($P<.05$) in crude protein, moisture and ash for group 3 *vs* group 1. Cattle in group 1 had approximately twice the fat content in the soft tissue compared to group 3.

Introduction

Present world grain shortages, likely increased future demands for grain for human consumption and potential change in the level of fat consumption in the human diet ultimately suggest a need for an alteration in beef production systems in the future. Recent trends in cattle feeding revealed that total grain use declined 50 percent between 1971 and 1974 with a concomitant 50 percent increase in the percentage of forages utilized in rations (Ward *et al.*, 1977). More recently, however, there has been some reversal in this sharp decline. Utilization of more forages in finishing rations for cattle will require additional tillable land for the production of high quality forages, since only high quality roughages will support adequate gains. Cool season annuals, such as wheat pasture, may offer great potential for producing forage-finished beef. Approximately 11.9 million acres of wheat pasture were available for grazing in Oklahoma and Texas in 1974.

Forage-finished beef yields smaller and leaner carcasses with less fat thickness, less internal fat and a lower dressing percentage than conventional grain-fed beef. Few studies have examined the detailed chemical composition of forage *vs* conventional grain-fed beef. The intent of this research was to examine the performance, carcass traits and chemical composition of cattle reared under widely different production systems.

Materials and Methods

Thirty Brangus X Hereford-Angus crossbred steers (avg. 768 lb), approximately 13 months of age, were allotted (10 per treatment) to one of three production systems: (1) a 90 percent conventional corn grain diet for 161 days;-(2) an intermediate group grazed on sorghum sudan and wheat pasture for 48 days, then fed on a 90 percent concentrate finishing ration for 113 days; or'(3) a mixture of sorghum sudan and wheat pasture (190 days) until slaughter (no grain). The slaughter endpoint of the trial was the age at which the animals reached a low choice slaughter grade or at the end of the normal production system. An attempt was made to minimize age differences at slaughter.

After slaughtering, carcasses from all three groups (production systems) were chilled for 48 hr or longer at 0 ± 1 C. Carcasses were evaluated prior to processing for conventional carcass measurements of dressing percentage, marbling, maturity, quality grade, ribeye area and average fat thickness (13th rib area), kidney, heart and pelvic fat and yield grade.

The right side of the carcass from groups 1 and 3 were divided into retail cuts and separated into bone, soft tissue and KHP fat. The soft tissue was thoroughly ground in

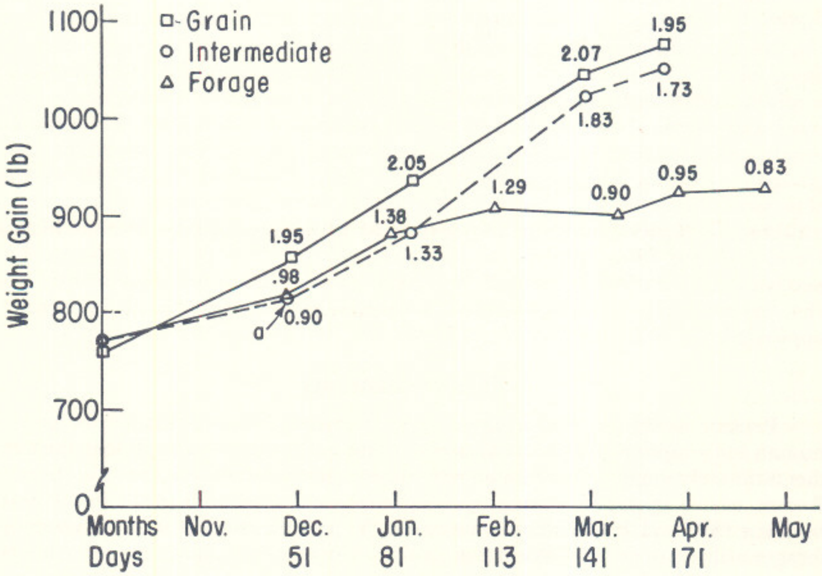

Figure 1. Growth curve for brangus crossbred steers on different production systems. The average daily gains appear on the respective growth curves.
[a]Signifies the end of the grazing period and the beginning of the feedlot phase for the intermediate group of cattle.

a meat grinder and then mixed in a mixer. A 40 pound sample was taken from the gound soft tissue for sampling purposes. The 40 pound sample was passed through a silent cutter to further mix and grind the soft tissue. Two samples (150 g) were taken at random from the soft tissue for proximate analysis. The samples were routinely analyzed for crude protein N by the Kjeldahl procedure (AOAC, 1970), moisture by the weight loss after drying at 100 C for 24 hr, fat content by ether extraction for 24 hr and ash content by ashing at 500 C for 3 hr (AOAC, 1970).

Results and Discussion

The performance of the three groups of cattle are shown in Figure 1. The average daily gains (ADG) for the conventional grain and intermediate fed cattle were 1.95 and 1.73 lb during the 161 days. During the 190 days, the steers grazing wheat pasture gained 160 lb (ADG .83 lb). The growth curves for the intermediate and forage fed cattle were similar up to mid-January (90 days) with the two groups attaining 41 percent and 75 percent, respectively, of their average slaughter weight. During January and February, excessive snowfall covered the wheat pasture, lowering performance of

Table 1. Composition of conventional grain ration.

Constituent	Percentage
Dry Rolled Corn	79.0
Soybean Meal	4.0
Cottonseed Hulls	5.0
Alfalfa Meal (Pelleted)	5.0
Molasses, Cane	5.0
Calcium Phosphate Dibasic	.4
Calcium Carbonate	.4
Salt (Plain)	.5
Urea	.7
	100.0%

Vitamin A (30,000 IU/g) supplement provided at .01% of the diet.

Table 2. Carcass data for brangus crossbred steers from various production systems.

Carcass Trait	Grain	Intermediate	Forage	SEM[e]
Hot Carcass wt, lb	675.9[a]	649.9[a]	504.7[b]	68.2
Dressing percentage	62.9[a]	61.8[a]	54.4[a]	
Maturity	14.1	14.0	13.8	.29
Marbling	14.8[a]	13.6[a]	9.0[b]	2.39
Quality Grade[d]	12.3[a]	12.1[a]	8.4[b]	1.01
Ribeye area, in^2	11.0[a]	10.5[ab]	9.6[b]	.87
Fat, in	.63[a]	.55[a]	.20[b]	.11
KHP %	3.9[a]	2.6[b]	1.6[c]	.65
YLDGRD	3.68[a]	3.36[a]	2.12[b]	.50

[abc]Means in a row with the same superscript letter differ ($P<.05$).
[d]12 = low choice, 9 = low good.
[e]Standard error of the mean.

Table 3. Proximate analysis of soft tissue from carcasses from the forage and grain-fed brangus crossbred steers.

Production System	Moisture	Dry Matter	Protein N	Fat	Ash
	%	%	%	%	%
Grain	49.80[a]	49.70[a]	14.95[a]	33.54[a]	.74[a]
Forage	64.43[b]	35.60[b]	18.75[b]	15.91[b]	.96[b]
SEM[c]	.68	.40	.10	.32	.006

[ab]Means in a column with different superscript letters differ ($P<.05$).
[c]Standard error of the mean.

the forage-fed group. During these months, the cattle were placed on sorghum stubble and provided with 2 lb cottonseed cake per day. During the last 30 days, the low ADG suggests that the grass-fed cattle had reached most of their growth potential and should have been slaughtered a month earlier. It appears that once forage-fed cattle of this type reach 900 to 930 lb, most of their potential for good gains on forage have been achieved.

Carcass data for the three groups are shown in Table 2. Carcass data for cattle in groups 1 and 2 was similar with the exception of percent KHP. The carcass parameters for the forage-fed steers were significantly lower ($P<.05$) than those of the other two groups with the exception of REA. The grain-fed and intermediate group graded 70 percent choice and 30 percent high good while the forage-fed steers graded 60 percent standard and 40 percent good. The carcass data and performance of cattle in group 3 compared less favorably to data from a previous year (Wagner and Horn, 1976) in which steers fed only wheat pasture gained 2.2 lb per day and carcasses graded 40 percent choice, 60 percent good.

Proximate analysis data for the soft tissue from cattle in groups 1 and 3 are shown in Table 3. The percent moisture, protein and ash were significantly higher ($P<.05$) in the soft tissue from forage-fed steer carcasses than from grain-fed steers. The percent fat and dry matter were significantly higher ($P<.05$) for the soft tissue from steers in group 1 than in group 3. The inverse relationship between percent fat and protein in the soft tissue of steers on the widely different production systems was expected. However, no explanation could be offered for the differences in ash content of soft tissue.

In conclusion, the differences in carcass characteristics and chemical composition of the soft tissue of steers on different production systems were greater than expected, reflecting the marginal wheat pasture conditions due to severe winter weather.

Literature Cited

A.O.A.C. Association of Official Analytical Chemists (14th Ed.), Washington, D.C.

Wagner, D. G. and F. Horn. 1976. Greater emphasis on forage in finishing programs. Ft. Reno Field Day Report.

Ward, G. M., P. L. Knox, B. W. Hobson. 1977. Beef production options and requirements for fossil fuel. Science 198:265.

Corn Moisture, Protein Concentration and Rumensin and Digestion by Feedlot Steers

S. R. Rust, F. N. Owens
D. R. Gill and R. W. Fent

Story in Brief

Sixteen steers (650 lb) were used to determine the effects of corn moisture, protein concentration and monensin (Rumensin) on ration digestibility and nitrogen retention. The steers were placed in metabolism stalls and fed rations of high moisture corn (HMC) or dry rolled corn at two protein levels (9.3 and 12.3 percent) with two monensin levels (0 and 30 g per ton of feed).

Monensin addition decreased feed intake and increased digestibility of dry matter, organic matter, starch and nitrogen. The higher protein concentration increased nitrogen retention and digestibility of dry matter, organic matter, nitrogen, starch and ash. HMC had greater digestibility of dry matter, starch and organic matter than dry corn but produced lower dry matter intake and nitrogen retention. Although no monensin-protein interaction was apparent, addition of either protein or monensin to the low protein ration enhanced digestibility. Consequently, monensin may "spare" protein by this action. Responses to monensin supplementation were greater for dry rolled than high moisture corn suggesting that monensin benefits may be greater with less processing of the grain.

Introduction

Gill *et al.* (1977) reported monensin exhibited a protein sparing effect at a low protein level with whole shelled corn rations. Monensin addition improved feed efficiency more with dry corn diets (Gill *et al.*, 1977) than with HMC diets (Gill *et al.*, 1978). Conversely, Utley *et al.* (1977) reported no corn moisture by monensin interaction. This study was conducted to determine how monensin might "spare" protein and whether corn moisture level influenced this response. Ration digestibility and nitrogen retention were examined.

Table 1. Ration composition[1].

Corn moisture	11		23	
Protein level	9.3	12.3	9.3	12.3
Corn	85.6	76.8	86.2	77.8
Corn silage	12.1	12.1	11.6	11.6
Soybean meal	---	9.1	---	8.6
Alfalfa dehy	.51	.51	.51	.51
Dicalcium phosphate	.08	---	.07	---
Calcium carbonate	1.00	1.00	.95	.96
Potassium chloride	.43	.44	.14	.14
Salt, mineralized	.28	.28	.27	.27
Vitamin A	.0008	.0008	.0009	.0009

[1] Ingredients in a percentage of the dry matter.

Materials and Methods

Sixteen Hereford and Angus steers (650 lb) were alternated among rations so that each steer received four of the eight different rations. The steers were fed free choice. The steers were placed in concrete-slatted pens for seven days adaptation and moved to metabolism stalls the final seven days of each period. Urine and feces were collected the last five days of each period. The high concentrate ration (Table 1) was composed of dry rolled or HMC, and on a dry matter basis provided two protein levels (9.3 and 12.3 percent) and two levels of monensin (0 and 30 g/ton of feed).

Results and Discussion

The effects of monensin are shown in Table 3. Averaged across both corn types and protein levels, monensin addition decreased dry matter intake by 12.3 percent. This is commonly observed and has been suggested as a conditioned response to some intestinal discomfort produced by monensin and may be associated by the animal with some odor or flavor in Rumensin. Digestibilities of dry matter, organic matter, starch and nitrogen were increased with monensin feeding. Monensin increased fecal pH and

Table 2. Analysis of ration ingredients.[a]

	Dry matter	Starch	Ash	Crude protein	Soluble nitrogen[b]
	%	%	%	%	%
High moisture corn	77.0	80.8	1.65	9.34	50.2
Dry rolled corn	89.1	76.0	1.96	9.66	23.6
Corn silage	32.9	22.9	7.44	7.11	72.9

[a]Ingredient analyses on a dry matter basis.
[b]Percentage of total nitrogen.

Table 3. Influence of monensin on metabolism.

Item	Monensin concentration 0	30 g/ton
Dry matter intake, g/day	4994[ab]	4381[c]
Digestibility, %		
Dry matter	81.2[b]	83.5[c]
Organic matter	82.2[b]	84.6[c]
Starch	96.5[f]	97.7[g]
Nitrogen	70.2[f]	72.6[g]
Ash	59.6	61.9
Nitrogen retention, g/day	32.6	29.6
Fecal		
pH	5.51[d]	5.77[e]
Starch, %	10.5	8.6
Ash, %	10.0	10.5
Urine output, g/day	4860	4293

[a]Each figure is the mean of 32 observations.
[bc]Means in a row with different superscripts differ statistically ($P<.025$).
[de]Means in a row with different superscripts differ statistically ($P<.05$).
[fg]Means in a row with different superscripts differ statistically ($P<.10$).

slightly decreased fecal starch content. Lower protein and energy intake with monesin feeding may explain the slightly lower nitrogen retention values observed with monensin. The increased dry matter and organic matter digestibilities can be explained totally by enhanced starch digestion. Higher fecal pH may be the result of less starch to ferment to acids in the large intestine.

Influence of corn moisture on digestion parameters is shown in Table 4. Consumption of HMC caused lower dry matter intake. This phenomenon has been associated with higher soluble nitrogen levels (Prigge, 1976). The soluble nitrogen for HMC was much greater than for dry rolled corn (Table 2.) Digestibility of dry matter, starch and organic matter was greater with HMC while ash digestibility was greater with dry

Table 4. Influence of corn moisture on metabolism.

Item	Corn moisture, %	
	11	23
Dry matter intake, g/day	5143[ab]	4234[c]
Digestibility, %		
Dry matter	81.18[b]	83.56[c]
Organic matter	82.01[d]	84.75[e]
Starch	95.48[b]	98.72[c]
Nitrogen	71.83	71.06
Ash	64.19[b]	57.28[c]
Nitrogen retention, g/day	34.20[b]	27.91[c]
Fecal		
pH	5.48[d]	5.80[e]
Starch, %	14.31[b]	4.86[c]
Ash, %	9.22[f]	11.29[g]
Urine output, g/day	4786	4367

[a]Each figure is the mean of 32 observations
[bc]Means in a row with different superscripts differ statistically (P<.05).
[de]Means in a row with different superscripts differ statistically (P<.025).
[fg]Means in a row with different superscripts differ statistically (P<.005).

Table 5. Influence of protein level on metabolism.

Item	Protein level, %	
	9.3	12.3
Dry matter intake, g/day	4523[a]	4852
Digestibility, %		
Dry matter	80.39[d]	84.35[e]
Organic matter	81.41[d]	85.34[e]
Starch	96.49[b]	97.71[c]
Nitrogen	66.35[d]	76.55[e]
Ash	58.74[b]	62.74[c]
Nitrogen retention, g/day	22.55[d]	39.57[e]
Fecal		
pH	5.69	5.59
Starch, %	10.30	8.87
Ash, %	9.86	10.65
Urine output, g/day	4329	4824

[a]Each figure is the mean of 32 observations.
[bc]Means in a row with different superscripts differ statistically (P<.10).
[de]Means in a row with different superscripts differ statistically (<.005).

corn. The increased dry matter and organic matter digestibility for HMC can be explained by higher digestibility of starch. Nitrogen retention was lower for steers fed HMC diet as compared to those fed dry corn. Fecal pH was higher when HMC was fed than when dry corn was fed.

Effects of additional protein are depicted in Table 5. The higher protein level produced greater digestibility of dry matter, organic matter, nitrogen, starch and ash. The increased nitrogen digestibility is probably the result of replacing ground corn by soybean meal in the diet. As protein from soybean meal is more digestible than that from corn, the ration change automatically increases protein digestibility.

Table 6. Influence of protein level and monensin on metabolism.

Protein level, %	9.3		12.3	
Monensin, g/ton	0	30	0	30
Dry matter intake				
g/day	4828[a]	4220	5162	4542
Digestibility, %				
Dry matter	78.99	81.80	83.42	85.50
Organic matter	79.98	82.05	82.86	86.25
Starch	95.59	97.41	97.39	98.03
Nitrogen	65.85	66.85	74.65	78.45
Ash	58.14	59.34	61.03	64.45
Nitrogen retention,				
g/day	27.31	17.79	37.81	41.32
Fecal				
pH	5.60	5.78	5.43	5.75
Starch, %	11.41	9.14	9.62	8.13
Ash, %	9.63	10.09	10.32	10.98
Urine output, g/day	4830	4890	3834	4758

[a]Each figure is the mean of 32 observations.

Table 7. Starch digestibility relationships.

Equation	R^2[a]
Starch digestibility = 82.6 + 2.57 (fecal pH)	.15
Starch digestibility = 101.0 - 0.41 (fecal starch)	.87

[a]Degree of relationship with no relationship being 0, and a perfect relationship being 1.00.

Table 8. Monensin responses.

Protein level, %	9.3		12.3	
Corn type	DRC	HMC	DRC	HMC
	---- Digestibility change, % ----			
Dry matter	+3.68[a]	+1.94	+3.66	-0.08
Organic matter	+5.04	+0.72	+2.24	+1.36
Starch	+3.28	+0.37	+1.45	-0.18
Nitrogen	+3.77	-1.78	+4.34	+3.27

[a]Digestibility with monensin was 79.54 and without was 75.86 for an increase of digestibility by 3.68. Similar calculations were used for other values.

Nitrogen retention was greater for the higher crude protein diet. Greater nitrogen retention may be the result of more available energy for growth due to slightly higher intakes and greater digestibility of the high protein diet. The influence of monensin at the two protein levels is shown in Table 6. Addition of either monensin or protein to the low protein ration enhanced digestibility of dry matter and starch. This increased energy availability may explain part of the "protein sparing" action of monensin.

Fecal pH proved to be a poor indicator of starch digestibility while fecal starch closely reflected starch digestibility (Table 7). This suggests that fecal starch may be one measurement which might be used to measure energy availability and predict feed efficiency under feedlot conditions.

Digestibility responses to monensin at the two protein levels for dry and HMC are shown in Table 8. Starch is the primary nutrient of interest from the grain being fed. The greater response to monensin with the low protein level and the dry grain in starch digestibility diets confirms earlier suggestions from feedlot trials (Gill *et all*., 1977, 1978). This indicateshat productivity response to monensin may be greater when grain has received less processing and ration protein is low.

Literature Cited

Gill, D. R., F. N. Owens, J. J. Martin, D. E. Williams and J. H. Thornton. 1977. Okla. Agr. Exper. Sta. Res. Rep. MP-101:42.

Gill, D. R., F. N. Owens, J. J. Martin, J. H. Thornton and D. E. Williams. 1978. 70th Annual Meeting Amer. Soc. Anim. Sci. Abstr., p. 419.

Prigge, E. C. 1976. High Moisture Grain Symposium Proc. Okla. State Univ., p. 76.

Utley, P. R., G. L. Newton, D. M. Wilson and W. C. McCormick. 1977. J. Anim. Sci. 45:154.

High Moisture Corn Additives

F. N. Owens, J. H. Thornton and K. B. Poling

Story in Brief

Six commercial additives plus propionate, monensin, formaldehyde, bentonite and NH_4OH were added to high moisture corn (26.9 percent moisture) as it was ensiled. Material fermented in double-lined plastic bags for 10 months prior to feeding to sheep and to chemical analysis. Two materials, Chemstor III and propionic acid, inhibited fermentation and also inhibited mold growth when fermented material was exposed to air. These materials also tended to reduce ruminal fermentation. Other additives had little effect on characteristics of the grain or acceptability by growing lambs.

Introduction

Last year, a group of commercial additives for corn silage were examined (Rust *et al*., 1978) and one material was tested further as reported elsewhere in this publication by Zinn. Scientific information is limited regarding many of the commercial additives for ensiling with good quality high moisture corn. Some are added as mold inhibitors, others for their nutrient or drug activity and others to enhance or inhibit fermentation. This study was designed to examine the influence of several commercial additives for high moisture corn on fermentation characteristics, stability and acceptability by growing lambs.

Materials and Methods

High moisture corn ground through a tub grinder with a half-inch screen was ensiled in plastic bags. After fermentation, samples were chemically analyzed. Each was fed free choice to six growing lambs for 28 days to evaluate acceptability and daily gain. Stability was measured by placing samples in a humidor and recording the number of days until mold growth first appeared and when the entire sample became moldy. Digestibility in the rumen was estimated by incubating the fermented high moisture corn with rumen fluid. Total digestibility was estimated by digesting the residue, obtained after the above rumen fluid digestion, with a pepsin-HCl mixture.

Results and Discussion

All high moisture corn preserved well and had a typical fermented odor with no evidence of mold growth. Table 1 presents results for the various additives plus the initial frozen sample. Even though frozen within six hrs of grinding, some fermentation had occurred, possibly between harvest and grinding.

Compared to the fresh material, fermentation increased lactate, solubility, and stability but decreased pH. Several additives, propionate, Chemstor III (a mix of propionate and formaldehyde) and formaldehyde decreased fermentation as measured by lactate level and protein solubility. Propionate and Chemstor III markedly increased stability (Table 2) against mold growth but also tended to reduce digestibility, especially in the rumen fermentation.

Table 1. Fermentation characteristics.

Item	% Level	Final dry matter	Lactate %	pH	Total N	N sol. % of Total N	NH_3 %
Frozen	---	73.1	1.36	5.31	1.49	19.2	.024
Control	---	73.1	2.85	4.28	1.44	43.7	.080
Mold inhibitors							
Propionate	.67	72.3	2.06	4.18	1.43	38.7	.056
Chemstor III	1.0	73.1	.92	4.51	1.44	19.9	.030
Formaldehyde	.30	71.8	1.52	4.92	1.55	31.2	.058
Feed additives							
Monensin	.0032	72.3	3.59	4.19	1.45	48.7	.077
Bentonite	.50	72.0	3.09	4.13	1.47	47.4	.085
NH_4OH	1.0	72.0	3.59	4.46	1.61	43.9	.183
Commercial products							
Silagain	.05	71.9	2.79	4.18	1.46	49.5	.091
Improvall	.05	71.4	2.86	4.16	1.39	53.6	.084
Sweetzyme	.0005	71.5	2.75	4.17	1.46	53.2	.087
Silogen	.075	71.4	2.76	4.17	1.45	52.9	.082
Fresh chop	.05	72.2	2.77	4.18	1.47	50.9	.096

Table 2. Stability, digestibility and lamb performance.

Item	Stability (days to mold) First	Stability (days to mold) Complete	Sheep gain g/day	IVDMD Ruminal	IVDMD Total	Intake #/sheep/day
Frozen	3.7	6.0	99.2	77.9	84.6	2.42
Control	8.7	19.7	107.6	80.4	86.0	2.24
Mold inhibitors						
Propionate	>77	>77	118.4	78.3	83.3	2.48
Chemstor III	>77	>77	69.4	74.8	82.1	2.36
Formaldehyde	8.0	14.0	88.0	82.4	87.0	2.56
Feed additives						
Monensin	7.0	18.0	64.1	82.2	87.6	2.40
Bentonite	8.7	13.0	68.0	78.8	84.4	2.15
NH_4OH	7.3	13.3	104.7	83.3	88.9	2.11
Commercial products						
Silagain	9.0	15.0	96.3	79.1	84.7	2.13
Improvall	8.7	15.3	75.8	82.1	86.8	2.24
Sweetzyme	11.0	18.3	99.9	80.4	87.8	2.37
Silogen	7.0	12.3	56.0	82.4	86.1	2.19
Fresh chop	16.0	26.7	70.4	82.8	87.5	2.34

Several additives, monensin (which might be incorporated into rations through ensiling), bentonite (which may reduce seepage loss by absorbing water) and NH_4OH (which is a low cost means of adding supplemental protein) increased lactate and tended to decrease stability. None of the additives had statistical effects on feed intake or rate of gain by sheep. Results suggest that if high moisture corn is properly ensiled, additives produce little if any benefit or detriment. Mold inhibiting chemicals containing propionic acid are available commercially and appear very effective.

Literature Cited

Rust, S. R., F. N. Owens, A. B. Johnson, B. J. Shockey and K. B. Poling. 1978. Okla. Agr. Exper. Stat. Res. Rep. MP-103:146.

Corn Moisture Level for Feedlot Steers

R. G. Teeter, F. N. Owens
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Story in Brief

Dry rolled corn (DC, 14 percent), low moisture (LMC, 20.2 percent), high moisture (HMC, 27 percent) and a mixture of half dry and half HMC grain (HD) were fed to 98 yearling steers in a 96-day finishing trial. Average daily gain and feed efficiency for steers fed DC, LMC, HMC and HD were 2.73, 2.51, 2.87 and 2.93 lb per day and 7.60, 8.99, 7.26 and 7.17 lb of feed per lb of gain. DC fed steers tended to have lower marbling scores but did not differ in dressing percentage, yield grade or number of liver abscesses. Dry matter, organic matter and protein digestibility slightly favored HMC. Fecal starch was least for steers fed HMC and greatest for steers fed LMC. Protein solubility and pepsin digestibility were greatest for the HMC followed by DC and LMC. Grinding of the corns increased digestibility in rumen fluid most with dry corn and low moisture corn. Urea addition also helped, most with the low moisture corn.

Introduction

The use of high moisture corn for feedlot steers has in recent years become increasingly common. High moisture corn is typically stored at 20 to 28 percent moisture in a pit silo in the ground or rolled form. For ease of handling and esthetic reasons (bright color, less odor), its moisture level has steadily declined the past 10 years. Occasionally, to stretch grain supplies, dry and high moisture corn are fed in combination but limited research information on the combination is available.

The purpose of this study was to examine the effects of corn moisture level and a 50:50 mixture of dry and high moisture corn on growth rate, feed efficiency and carcass characteristics of feedlot steers.

Experimental Procedure

A 96-day finishing trial was conducted with 98 yearling black baldy steers which were allotted to 12 pens, three pens per treatment. The four treatments evaluated were as follows: dry (14 percent moisture), two high moisture (20.2 and 27 percent) and a mixture of half 27 percent and half 14 percent moisture corn grain.

Harvested corn was selected on the basis of moisture to be ensiled in large horizontal plastic bags. Rations contained, as a percent of dry matter-83 percent rolled corn, 14 percent alfalfa hay and three percent of a urea-mineral-monensin supplement. Steers were implanted with Synovex-S at the start of the trial. Final weights of steers were calculated from carcass weight using a standard dressing percent of 62 percent. *In vivo* dry matter digestibility was estimated from acid insoluble ash content of feeds and fecal grab samples.

Results and Discussion

All corn was well preserved. On removal from storage, HMC remained cool whereas LMC would heat. This indicates less fermentation and poorer bunk stability of the LMC.

Feed intake and feed required per pound of gain was greater (Table 1) for steers fed LMC than for those fed DC, HMC or HD. Steers fed LMC had lower weight gains

Table 1. Steer performance and carcass characteristics.

Item	Dry corn	Low moisture corn	High moisture corn	HMC & dry corn
Feed intake, lb/day	20.79	22.60	20.81	21.01
ADG, lb/day	2.73	2.51	2.87	2.93
Feed/gain	7.60	8.99	7.26	7.17
Dressing, %	61.9	61.4	61.8	62.2
Yield grade	2.5	2.4	2.5	2.6
Liver abscesses	1.00	0.66	1.67	1.67
Marbling score	14.9	16.8	17.2	16.2

Table 2. Digestibility by feedlot steers.

Item	Dry corn	Low moisture corn	High moisture corn	HMC + Dry corn
In vivo digestibility, %				
Dry matter	70.0	70.1	74.5	70.6
Organic matter	72.5	73.7	76.3	71.5
Protein	52.1	56.5	65.3	60.4
Nutrient content				
Fecal starch, % DM	8.7	11.7	5.2	7.0
% disappearance	96.7	94.5	97.7	97.1
Fecal pH	6.29	6.39	6.75	6.66

than those fed HMC or the HD mixture and slightly less than those fed DC. Differences (Table 1) were not detected in dressing percentage, yield grade or number of liver abscesses. Marbling scores tended to be lower for steers fed DC.

Digestibility of dry matter, organic matter and protein tended to increase with increasing corn moisture content (Table 2). Fecal starch was lower for steers receiving HMC than LMC, suggesting that starch from LMC was less completely digested. The highest fecal pH observed was associated with the HMC and fecal pH tended to decline ($r^2 = 0.64$) as fecal starch increased. Nitrogen solubility in a buffer solution was greater for HMC than for LMC and DC (Table 3). Similarly, pepsin digestibility was highest ($P<.05$) for HMC.

Dry matter digestibility by ruminal fluid was determined for the DC, LMC and HMC in the unground or whole (W), and the ground (G) state with (+U) and without urea (Table 4). Grinding increased digestibility at each moisture level, especially for DC and LMC. Urea addition also enhanced ruminal digestibility, especially for the LMC.

Results indicate that efficiency of corn use by feedlot steers varies markedly with corn moisture level. At high (27 percent) and low (14 percent) moisture levels nutrient availability appears to be satisfactory while at the intermediate moisture level (20.2 percent) nutrient availability was depressed. Although the steers attempted to compensate for the decreased availability of the LMC with an increased intake, they failed

Table 3. Laboratory characteristics.

Item	Dry corn	Low moisture corn	High moisture corn
Buffer protein solubility, %	18.7	15.2	41.1
Pepsin digestibility, %	87.5	84.6	89.3
pH	----	4.6	4.0

Table 4. Digestion by rumen fluid.

Item	Dry corn	Low moisture corn	High moisture corn
	%	%	%
Unground	49.95	55.14	55.45
+ urea	55.47	61.48	59.64
Ground	61.51	60.19	58.50
+ urea	69.21	72.95	67.51

to achieve the rate of gain of the steers fed DC or HMC. Elevated fecal starch suggest that lowered energy availability was involved. Fecal starch, daily gain and feed efficiency all ranked the corn moisture levels in the same order from best to worst.

As in work conducted by Davis *et al*. (1978) at Kansas State University, associative effects between dry and high moisture corn in this trial were not evident. This suggests that combinations of corns with varying moisture can be satisfactorily fed but have no great advantage over the mean of the two individual types of corn.

Literature Cited

Davis, George V., Jr. and Gerald L. Greene. 1978. Garden City Branch, Kans. State Univ. Cattle Feeders' Day, p. 1.

Protein Sources and Levels for Dry and High Moisture Corn

D. R. Gill, J. J. Martin
A. B. Johnson, F. N. Owens
and D. E. Williams

Story in Brief

Corn grain, in the rolled or high moisture form, was fed with supplemental protein from urea or soybean meal at two levels of protein (10.5 and 11.5 percent of dry matter). One hundred ninety-one 698 lb steers were fed these rations for 133 days. Compared with dry corn, high moisture corn produced superior rates and efficiencies of gain (5.2 and 3.2 percent). This was all attributed to the first two months on feed. Urea supplementation proved quite superior to soybean meal for steers fed dry corn (+11.1 and 5.8 percent) but slightly inferior for those fed high moisture corn (-3.5 and -1.7 percent). The higher level of protein improved performance slightly during the first 66 days of the trial but did not prove beneficial for the total trial.

Introduction

The effect of level and source of protein with *dry* corn grain upon performance of feedlot steers was examined by Gill *et al.* (1977). Similar work by Martin *et al.* (1978) using *high moisture* corn noted less response to higher protein levels. Since animal types and weights differed in those two trials, a more direct comparison of responses to protein with dry rolled and higher moisture corn was needed. This experiment, conducted at Panhandle State University, was designed to study the effects of corn moisture, level of protein and source of supplemental protein on performance of steers under feedlot conditions.

Table 1. Ration composition.

	Dry corn				High moisture corn			
Protein level, %	**10.5**	**10.5**	**11.5**	**11.5**	**10.5**	**10.5**	**11.5**	**11.5**
Protein source	**SBM**	**Urea**	**SBM**	**Urea**	**SBM**	**Urea**	**SBM**	**Urea**
Corn	83.66	83.66	81.33	83.66	83.66	83.66	81.33	83.66
Alfalfa hay	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Supplement	3.24	3.34	5.67	3.34	3.34	3.34	5.67	3.34
Corn	.84	1.32	.85	.94	---	---	---	.80
Soybean meal	.52	---	3.06	---	1.47	---	3.97	---
Salt	.45	.47	.45	.47	.47	.47	.45	.47
Alfalfa, Dehy.	.39	.40	.40	.40	.40	.40	.40	.40
Limestone	.39	.37	.40	.40	.40	.40	.40	.40
Molasses	.29	.31	.31	.30	.30	.30	.31	.31
KCL	.09	.13	.03	.13	.10	.13	---	.13
Dical	.03	.20	.17	.27	.20	.27	.17	.27
Rumensin[a]	+	+	+	+	+	+	+	+
Vitamin A	+	+	+	+	+	+	+	+
Urea	---	.07	---	.40	---	.17	---	.53

[a]Fed at 20 g/ton of feed.

Materials and Methods

One hundred ninety-one steers with an average weight of 698 lbs were allotted to 24 pens. They were fed free choice a ration (Table 1) calculated to provide either 10.5 or 11.5 percent protein on a dry matter basis. The rations contained 13 percent ground alfalfa hay, 81 to 83 percent corn grain and 3.3 to 5.7 percent supplement. Supplemental protein came from soybean meal or urea. The two levels of corn moisture were 15.7 and 26.5 percent. Dry matter of the grain was measured weekly and the ratio of corn to other ingredients adjusted to maintain a constant ration on a dry matter basis.

On day 110 of the trial, chromic oxide was added to all supplements and on day 117 fecal grab samples were obtained from at least three steers per pen for pH, starch, chromium and dry matter determination. Steers were slaughtered after 133 to 134 days on feed and carcass measurements were obtained.

Results and Discussion

Corn moisture level

The higher corn moisture (HMC) level produced 7.8 percent greater gain over the first 66 days (Table 2). However, this effect was not retained after this period. Over the 133 days, gain was greater by 5 percent for steers fed the high moisture corn.

Intake of the dry corn ration decreased after the first 66 days by 1.29 lb of dry matter per day or 6.5 percent whereas HMC intake remained constant. For the complete trial, the HMC steers ate .43 lb more dry matter per day. Feed efficiency favored the HMC the first 66 days by 9 percent but tended to favor dry corn the remaining period, so the feed efficiency advantage was diluted to 3.2 percent by the end of the trial.

Table 2. Steer performance results.

	Corn moisture		Protein source		Protein level	
Item	Dry	High Moisture	Soybean meal	Urea	10.5	11.5
Animals, no.	96	95	95	96	95	96
Pens, no.	12	12	12	12	12	12
Weight, initial	695	701	694	702	700	696
Daily gain						
0-66	3.61^{a}	3.89^{b}	3.72	3.78	3.68	3.82
66-final	2.85	2.94	2.81	2.97	2.96	2.82
0-final	3.23^{a}	3.40^{b}	3.26	3.37	3.31	3.32
Daily feed						
0-66	19.99	19.65	19.69	19.95	19.65	19.99
66-130	18.70^{a}	19.87^{b}	19.20	19.37	19.33	19.24
0-final	19.34^{a}	19.77^{b}	19.45	19.66	19.50	19.61
Feed/gain						
0-66	5.56^{a}	5.06^{b}	5.32	5.29	5.37	5.25
66-final	6.64	6.80	6.85	6.58	6.58	6.84
0-final	6.01^{c}	5.82^{d}	5.98	5.85	5.89	5.93
Fecal starch	17.9	17.7	18.3	17.4	17.9	17.7
Est. DMD	65.6	67.2	62.9^{a}	69.5^{b}	67.0	65.6
Fecal pH	5.67	5.86	5.62	5.90	5.65	5.89
NE_g meg/kg	1.40^{a}	1.44^{b}	1.41	1.44	1.43	1.42

[ab]Means in a row within a trial with different superscripts differ statistically ($P<.05$).
[cd]Means in a row within a trial with different superscripts differ statistically ($P<.10$).

Carcass weight (Table 3) was higher for the HMC cattle as were rib eye area and fat thickness at the 12th rib. Marbling also tended to be higher for steers fed HMC. Some of these carcass effects may simply be due to the greater carcass weight.

Dry matter digestibility and calculated metabolizable energy tended to favor the HMC, but some of the increased performance and feed efficiency with the HMC fed cattle can be attributed to higher dry matter intake.

Protein source

As judged across both ration moisture levels, average daily gain, daily feed intake and feed efficiency were not affected by source of supplemental protein. Unexplainably, dry matter digestibility was 9.5 percent higher with urea than with soybean meal as the supplemental protein source. During the period of sampling, feed efficiency was slightly superior for steers fed urea. Dressing percentage and carcass weight were also higher for the urea treatment. Historically steers fed urea have had reduced feed intake and rate of gain initially with compensation later in the trial. No evidence of such an "adaptation" period was observed in this trial.

An interaction between protein source and corn moisture was evident (Table 4). Throughout the trial, urea addition proved superior to soybean meal supplementation for rate of gain and feed efficiency with dry corn but soybean meal was superior to urea for HMC. If digestion is limited by available ruminal ammonia for digestion and synthesis of microbial protein, the higher nitrogen solubilities of HMC or urea supplementation should prove beneficial, but the combination is not necessary and could reduce intake slightly.

Protein level

The higher protein level improved gain and feed efficiency slightly the first 66 days of the trial but overall performance was equal. An interaction between protein source and protein level was observed for feed efficiency in the second half of the trial.

When protein was changed from 10.5 to 11.5 percent, feed required per lb of gain increased with added urea (6.26 to 6.91 lb) whereas it decreased with added soybean meal (6.93 to 6.79 lb). This suggests that excess urea may reduce efficiency of feed use of

Table 3. Carcass characteristics.

	Corn moisture		Protein source		Protein level	
Item	Dry	High moisture	Soybean meal	Urea	10.5	11.5
Dressing percentage	61.62	61.36	61.13[a]	61.84[b]	61.49	61.49
Carcass weight	699[a]	716[b]	701[a]	714[b]	709	706
Rib eye area						
Sq. in	12.62[a]	13.27[b]	12.79	13.09	12.95	12.94
per cwt.	1.81	1.86	1.83	1.84	1.83	1.84
KHP	2.94	2.98	3.00	2.93	2.95	2.97
Fat thickness	0.42[a]	0.50[b]	0.47	0.46	0.45	0.47
Marbling	14.1	14.4	14.4	14.1	14.2	14.3
Grade	12.7	13.0	12.9	12.8	12.7	12.9
Cutability, %	50.38	50.22	50.20	50.40	50.36	50.24
Abscesses	0.94	1.07	1.07	0.94	0.82[a]	1.19[b]
Yield grade	3.07	3.41	3.25	3.24	3.21	3.27
Percent choice	70.8	74.9	73.8	71.9	69.7	76.0

[ab]Means in a row within a trial with different superscripts differ statistically (P<.05).

Table 4. Interactions of corn moisture level and protein supplement source on steer performance.

Item	Dry corn		HMC	
	SBM	Urea	SBM	Urea
Daily gain, lb				
0-66 days	3.52[a]	3.70[ab]	3.91[b]	3.87[b]
66-133 days	2.60[a]	3.09[c]	3.03[bc]	2.84[b]
0-133 days	3.06[a]	3.40[b]	3.46[b]	3.34[b]
Feed intake, lb				
0-66 days	19.60[a]	20.37[b]	19.79[ab]	19.53[a]
66-133 days	18.31[a]	19.09[ab]	20.09[b]	19.65[ab]
0-133 days	18.95[a]	19.73[b]	19.94[b]	19.60[b]
Feed efficiency				
0-66 days	5.57[b]	5.54[b]	5.07[a]	5.05[a]
66-133 days	7.06[b]	6.22[a]	6.64[ab]	6.95[b]
0-133 days	6.19[b]	5.83[a]	5.77[a]	5.87[a]
NE_g, meg/kg	1.36[a]	1.44[b]	1.45[b]	1.44[b]

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

finishing feedlot steers as earlier results had suggested (Martin *et al.*, 1976) but contrasting with conclusions from Nebraska (Schindler and Farlin, 1979).

Rate of gain and feed efficiency responses to added protein for light steers has been observed consistently in previous trials (Gill *et al.*, 1977; Martin *et al.*, 1978). In those trials, initial weights were considerably less (574 lb; 483 lb) than in this trial (698 lb). In the earlier trials, response to elevated protein levels had disappeared by the time a weight of 750 lb was reached.

Liver abscess score, a combination of incidence and severity, was increased at the higher protein level. This has been noted in some earlier trials as well (Martin *et al.*, 1976; 1977) and could be associated with increased stress of the liver for ammonia detoxication with higher protein intakes.

Results suggest high moisture corn produces faster and more efficient gains than dry corn for steers under 850 lb; urea is more useful with dry than high moisture grain, excess urea should be avoided for heavier weight steers; and a protein level of 10.5 percent is adequate for yearling steers over 750 pounds. Phase feeding programs using a soybean-supplemented high moisture corn, high protein level for steers under 900 lb followed by a urea-supplemented, dry rolled or whole shelled corn, lower protein ration deserves further testing.

Literature Cited

Gill, D. R., F. N. Owens, J. J. Martin, D.E. Williams and J.H. Thornton. 1977. Okla. Agr. Exper. Sta. Res. Rep. MP-101:42.

Martin, J. J., F. N. Owens and D. R. Gill. 1976. Okla. Agr. Exper. Sta. Res. Rep. MP-96:87.

Martin, J. J., F. N. Owens, D. R. Gill and J. H. Thornton. 1977. Okla. Agr. Exper. Sta. Res. Rep. MP-101:47.

Martin, J. J., F. N. Owens, D. R. Gill, J. H. Thornton and D. E. Williams. 1978. Okla. Agr. Exper. Sta. Res. Rep. MP-103:87.

Schindler, Gregory E. and Stanley D. Farlin. 1979. Nebr. Beef Cattle Rep. p. 8.

Milo *vs* Corn at Two Moisture Levels

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Story in Brief

Corn and milo in the high moisture harvested or dry form were fed to finishing steers for 133 days. Compared with dry milo, dry corn produced 29 percent faster and 23 percent more efficient gains. Net energy for gain of the dry milo ration was only 80 percent that of the dry corn ration. Gain and efficiency of feed use were lower the first half of the trial for steers fed high moisture milo than those fed high moisture corn, but for the total trial, performance of steers fed high moisture harvested milo was almost identical to that of steers fed high moisture corn. Results suggest that benefit of high moisture harvest, like steam flaking, is much greater for milo than for corn grain.

Introduction

The feed grain of choice for cattle feeding in the Great Plains for the past 10 years has been corn. Consistent chemical composition and nutritional value plus less costly processing are probably the major reasons. But with increasing costs for fuel to pump water for irrigation, declining water tables and governmental price supports, many acres previously producing corn are now producing milo. This trial was designed to further examine the relative feeding value of dry rolled corn, dry ground milo, high moisture harvested corn and high moisture harvested milo.

Materials and Methods

Chemical compositions of the grains are shown in Table 1. Three pens of eight steers each were fed for 133 days the four grains (DC, DM, HMC, HMM) with a urea supplement to provide 11.5 percent protein. Experimental procedures are reported in the "protein level and source" article elsewhere in this publication. The variety of milo harvested and ground into the horizontal plastic bag silo and that ground for dry feeding were identical.

Results and Discussion

Despite high dry matter intake, performance of steers fed the dry ground milo was very poor (Table 2). Energy availability for gain from dry milo was only 80 percent that of dry corn. In contrast, high moisture milo had 98 percent the energy value of HMC and 99 percent the value of dry rolled corn. Gains were slower at the start of the trial with HMM than with HMC and DC. Feed efficiencies generally paralleled performance. Fecal starch was higher for milo than corn rations and particularly high with

Table 1. Grain and ration composition.

	Dry		High moisture	
Grain	Corn	Milo	Corn	Milo
pH	----	----	4.72	4.17
Dry matter, %	86.4	89.6	74.6	72.5
Crude protein, %	9.07	10.15	8.82	10.55
Ration protein, %	11.02	11.55	11.45	11.91

Table 2. Animal performance and carcass characteristics.

Form	Dry		High moisture	
Grain	Corn	Milo	Corn	Milo
Steers, no.	24	24	24	24
Pens, no.	3	3	3	3
Weight, initial	693	706	701	710
Daily gain, lb				
0-66	3.87[c]	2.95[a]	3.91[c]	3.57[b]
66-133	2.87[bc]	2.31[a]	2.73[b]	3.03[c]
0-133	3.37[b]	2.62[a]	3.30[b]	3.29[b]
Daily feed, lb				
0-66	20.86[b]	20.34[ab]	19.43[a]	20.14[ab]
66-133	19.07	20.09	19.46	19.97
0-133	19.96	20.21	19.44	20.05
Feed/gain				
0-66	5.41[ab]	6.91[c]	4.98[a]	5.66[b]
66-133	6.67[a]	8.76[b]	7.15[a]	6.60[a]
0-133	5.95[a]	7.70[b]	5.90[a]	6.10[a]
Carcass weight, lb	710[a]	655[b]	708[a]	712[a]
Grade	12.6[b]	11.9[a]	13.2[c]	12.9[bc]
Marbling	13.8[b]	12.5[a]	14.3[b]	14.4[b]
Fecal pH	5.90	5.85	6.07	5.89
Fecal starch, %	14.9[a]	28.3[b]	16.3[a]	21.9[ab]
Estimated digestibility, %	67.9[b]	58.0[a]	71.1[b]	68.3[b]
NE_g mcal/kg	1.41[a]	1.13[b]	1.43[a]	1.40[a]

[abc]Means within a trial with different superscripts differ statistically ($P<.05$).

dry milo. Dry matter digestibility for the dry milo ration was only 84 percent that of other rations, matching well with performance data. Marbling and federal grade tended to be higher for steers fed high moisture feeds.

Results suggest that high moisture harvest and storage of milo is one means of markedly enhancing its feeding value. However, the rapid rate of drying in the field of high moisture milo reduces the time available for harvest as compared with high moisture corn. Whether reconstitution of milo can completely restore this energy availability is unknown.

Ammonia, ChemStor and Formaldehyde Treated High Moisture Corn Grain for Feedlot Steers

J. H. Thornton, D. R. Gill,
J. J. Martin, F. N. Owens
and D. E. Williams

Story in Brief

Addition of 0.1 percent ammonia to high moisture corn at ensiling increased feed intake and rate of gain slightly with a low protein ration. Efficiency of feed use was unchanged by ammonia addition to high moisture corn or high moisture milo when an adequate protein level was fed. ChemStor III treated high moisture corn preserved well but had slightly lower feeding value than ensiled high moisture corn. Formaldehyde treatment of high moisture corn depressed gain and efficiency of feed use when fed in a low protein ration.

Introduction

Laboratory results with addition of aqueous ammonia added to high moisture corn (Thornton *et al.*, 1977) indicated that low level additions (below 0.3 percent) stimulate or extend fermentation; higher levels (above 0.5 percent) elevate the pH and inhibit fermentation. ChemStor III, a mixture of propionic acid and formaldehyde, is a commercial silage preservative produced by Celanese Corporation, New York, New York. Formaldehyde also has been used to treat protein and preserve forages. These trials were designed to determine the influence of these additives and several levels of ammonia addition on performance of feedlot steers.

Materials and Methods

Trial 1

Whole shelled corn containing 24 percent moisture from a common source was treated with chemicals; 1) 1 percent ChemStor III (67 percent propionic acid, 10 percent formaldehyde and 3 percent methanol), 2) .1 percent formaldehyde, 3) .3 percent ammonia (ammoniated water) with a calibrated applicator mounted on a 6 inch by 30 foot motor drive auger or, 4) left untreated. The corn was then ground with a tub grinder and transported to Panhandle State University, Goodwell, Oklahoma for storage. In excess of 25 tons of each treated corn plus an untreated control corn were stored in four silos and covered with plastic for three months prior to feeding. ChemStor and formaldehyde treated HMC were stored in upright cement silos while the others were packed in horizontal cement pits.

For the feedlot evaluation, 60 steers (535 lbs) were allotted to 12 pens at the Goodwell Station with the four corn treatments assigned to three pens each for the 84-day feeding trial. One supplement (Table 1) and corn silage were fed with the corn to provide the ration shown in Table 1. Rations were mixed and fed twice daily at levels to achieve maximum intake. The ration crude protein was designed to be suboptimal (10.2 percent of dry matter) to maximize response to supplemental protein. Animals were weighed a 28-day intervals during the trial. Initial shrunk and final weights adjusted to a constant carcass dressing percent were used to calculate daily gain and feed efficiency.

Trial 2

Experimental procedures duplicated those of the report on "Protein Sources and Levels" reported by Gill *et al.* elsewhere in this publication. High moisture corn was treated with 0.1 or 0.5 percent ammonia and fed to three pens of 8 steers each with the 11.5 percent protein urea supplement Gill *et al.* described. Additionally, three pens were fed the 0.5 percent ammonia-treated corn with the 10.5 percent protein supplement. High moisture milo was also treated with 0 or 0.1 percent ammonia and fed to three pens of eight steers each.

Results and Discussion

Trial 1

The effects of treatment on chemical composition are presented in Table 1. Dry matter was higher in the silages placed in upright silos, possibly attributable to more evaporative loss during filling and storage. Addition of 0.1 percent NH_3 should increased protein content by 0.5 percent, indicating a 73 percent loss in experiment 1 and a 14 percent loss in experiment 2. Soluble nitrogen content was lower with formaldehyde addition, indicative of binding of protein, while it was increased by ammonia addition. The ChemStor treated corn was fresh and bright while others tended to mold and heat when exposed to air. Ammonia-treated corn was quite dark in color.

Daily gain was greatest for steers fed the ammonia-treated and lowest for those fed formaldehyde-treated corn (Table 2). Feed efficiency was poorest for the steers fed

Table 1. Chemical composition of treated grains.

Item	Level	pH	Dry matter	Crude protein	Soluble protein[a]
Experiment 1			%	%	
Control	0	4.70	76.8	8.3	19.8
ChemStor	1.0	4.87	79.8	8.3	8.8
Formaldehyde	0.1	5.07	79.8	8.7	12.9
NH_3	0.3	6.48	77.3	8.7	22.4
Experiment 2					
HMC	0	4.72	74.6	8.82	----
HMC + NH_3	0.1	4.76	76.5	9.32	----
HMC + NH_3	0.5	8.14	76.2	11.03	----
HM Milo	0	4.17	72.5	10.55	----
HMM + NH_3	0.1	4.47	72.1	10.92	----

[a]Percent of total N.

Table 2. Steer performance.

Item	Control	ChemStor III	Formaldehyde	NH_3
Steers, No.	15	15	15	15
Daily gain, lb	3.13[ab]	3.13[ab]	2.88[a]	3.37[b]
Daily feed, lb	17.46	18.37	18.46	18.49
Feed/gain	5.58[a]	5.88[ab]	6.40[b]	5.50[a]
NE_g mcal/kg	1.21[a]	1.13[bc]	1.07[c]	1.22[a]

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

Table 3. Performance of steers fed ammoniated high moisture corn and high moisture milo.

Grain	Corn					Milo	
Protein level, %	11.5	11.5	11.5	10.5	10.5	11.5	11.5
Ammonia, %	0	0.1	0.5	0	0.5	0	0.1
Steers, no., lb	24	24	23	24	24	24	24
Pens, no.	3	3	3	3	3	3	3
Weight, initial, lb	701	703	711	710	703	710	707
Daily gain, lb							
0-66	3.91	3.57	3.76	3.84	3.58	3.57	3.42
66-134	2.73	3.11	2.78	2.94	2.92	3.03	2.75
0-134	3.30	3.33	3.26	3.38	3.24	3.29	3.07
Daily feed, lb							
0-66	19.43	18.76	20.52	19.63	19.51	20.14	19.60
66-134	19.46^{a}	20.41^{ab}	20.82^{b}	19.85^{ab}	19.94^{ab}	19.97^{ab}	19.39^{a}
0-134	19.44^{a}	19.60^{ab}	20.67^{b}	19.74^{ab}	19.73^{ab}	20.05^{ab}	19.49^{ab}
Feed/gain							
0-66	4.98^{a}	5.28^{abc}	5.48^{b}	5.12^{ab}	5.45^{abc}	5.66^{c}	5.75^{c}
66-134	7.15^{ab}	6.60^{a}	7.52^{b}	6.74^{ab}	6.84^{ab}	6.60^{a}	7.10^{ab}
0-134	5.89^{ab}	5.88^{ab}	6.37^{c}	5.84^{a}	6.09^{abc}	6.10^{abc}	6.34^{bc}
Fecal starch, %	16.3	16.6	20.5	18.3	16.7	21.9	15.0
Fecal pH	6.06	5.96	5.85	5.83	5.81	5.89	6.23
DMDDig.	71.1	66.3	66.8	70.1	73.2	68.3	72.3
Starch Dig., %	91.8	90.2	88.4	91.1	92.2	88.2	92.8
NE_g, meg/kg	1.43	1.42	1.34	1.44	1.35	1.40	1.35

[abc]Means within a trial with different superscripts differ statistically (P<.05).

Table 4. Carcass characteristics of steers fed ammoniated high moisture corn and high moisture milo.

Grain	Corn					Milo	
Protein level, %	11.5	11.5	11.5	10.5	10.5	11.5	11.5
Ammonia, %	0	0.1	0.5	0	0.5	0	0.1
Carcass weight, lb.	708	711	710	719	704	712	692
Rib eye area, in²	13.63[b]	13.47[b]	12.65[a]	13.17[ab]	13.24[ab]	13.01[ab]	12.87[ab]
Fat thickness, in²	0.50	0.42	.49	.45	.46	.50	.52
KHP, %	2.83	2.94	2.82	2.92	2.88	2.93	2.81
Cutability, %	50.65	50.90	49.94	50.45	50.57	50.11	50.11
Abscesses	1.13	1.00	.79	1.00	1.00	1.38	1.25
Yield	3.52[b]	3.28[ab]	3.20[a]	3.23[a]	3.33[ab]	3.35[ab]	3.39[ab]
Marbling	14.29	14.67	14.56	15.16	13.58	14.36	14.04
Quality	13.21	12.83	13.21	13.00	12.42	12.91	12.92

[ab]Means within a trial with different superscripts differ statistically ($P < .05$).

formaldehyde-treated corn. Ammonia addition increased feed intake and rate of gain slightly, possibly because of the extra protein supplied since this was a low-protein ration.

Trial 2

With the high level of ammoniation, HMC had a strong ammonia odor. Rate of gain was not influenced by ammoniation of high moisture corn or milo (Table 3). Efficiency of feed use tended to decrease with ammoniation of the grain. Calculated net energy for gain was decreased a mean of 4 percent by the low level and 6 percent by the high level of ammonia addition. With the higher protein and higher ammonia level, rib eye area and yield grade were reduced (Table 4) although live and carcass weights were unchanged.

Results show no promise of enhancing the nutritive value of high moisture grains by ammonia addition. Odors made handling of 0.5 percent ammoniated corn distasteful, but did not reduce acceptability by steers.

Literature Cited

Thornton, J.H., F.N. Owens and M. Arnold 1977. Okla. Agr. Exp. Sta. Res. Rep. MP-101, p. 173.

Ronnel or Monensin for Feedlot Heifers

F. N. Owens, D. R. Gill and R. W. Fent

Story in Brief

Ronnel was fed with an 89 percent whole shelled corn ration to 140 growing heifers in a 137 day trial. Ronnel at 64 g per ton of feed tended to increase rate of gain (3.6 percent). No effects on carcass composition were apparent. Monensin at 30 g per ton of feed improved rate of gain (7.2 percent) and feed efficiency (11.1 percent).

Introduction

Ronnel[1] has been used for many years as a heel fly, horn fly and lice control agent for cattle. Trials from Kansas and Montana suggest that feeding of Ronnel at 64 to 96 g per ton may enhance rate of gain and feed efficiency of feedlot steers by 3 to 8 percent. This trial was designed to determine the influence of Ronnel on growth rate and feed efficiency of feedlot heifers. Three levels of Ronnel and one level of monensin were tested in the feeding study.

Experimental Procedures

One hundred-forty charolais by black badly heifers, mean initial weight of 679 lbs, were stratified by weight and randomly allotted, seven per pen, to 20 pens. Four pens

[1]Trade mark of Dow Chemical Co., Midland, MI.

were randomly assigned to each treatment. Treatments consisted of a negative control, three levels of supplemental Ronnel (64, 80 and 96 g per ton) sprayed onto the feed during the final mixing, and one level of monensin (30 g per ton) incorporated into the pelleted supplement. Ration composition is presented in Table 1.

At the start of the trial, heifers were vaccinated for bovine rhinotracheitis, leptospira pomona, bovine virus diarrhea, parainfluenza 3, blackleg, malignant edema and were dewormed with thiabendazole paste following trucking from Arnette, Okla.

Feed was available *ad libitum* from self-feeders which were filled every four to seven days. On weigh-days, all feed was removed manually, weighed and re-fed. Feed samples were taken at each feeding and composited for analysis.

Cattle were weighed initially following 20 hr with neither feed nor water. Cattle were weighed full at subsequent 28-day intervals. On day 136, heifers were trucked to Oklahoma City for slaughter and carcass data were obtained. Final weights were calculated from hot carcass weight assuming a dressing percentage of 62 percent.

Table 1. Ration composition.

Ingredient	%
Whole shelled corn	89
Cottonseed hulls	5
Urea supplement	6

Table 2. Animal performance.

	Ronnel				Monensin
	0	64	80	96	30
Animals, no.	28	28	28	28	28
Pens, no.	4	4	4	4	4
Weight					
Initial	678	682	681	678	678
56 day	873	897	878	884	879
112 day	1052	1084	1064	1062	1082
135 day	1135	1154	1146	1136	1167
Adj. final	1091	1107	1093	1096	1117
Daily gain, lb					
0-56	3.49	3.83	3.51	3.68	3.58
56-137	3.23[a]	3.18[a]	3.31[ab]	3.11[a]	3.57[b]
0-137	3.33	3.45	3.42	3.34	3.57
Feed intake, lb					
0-56	21.56[b]	21.43[b]	21.48[b]	21.31[b]	19.58[a]
56-137	23.93	23.96	23.68	23.06	23.16
0-137	22.96[b]	22.93[b]	22.78[ab]	22.34[ab]	21.70[a]
Feed/gain					
0-56	6.23	5.61	6.16	5.80	5.51
56-137	8.94	9.31	9.04	8.84	7.91
0-137	7.64[b]	7.40[ab]	7.62[b]	7.33[ab]	6.79[a]

[ab] Means with different superscripts differ statistically ($P<.05$).

Results and Discussion

Daily gain and feed/gain for the first 56 days were improved slightly 5.3 and 6.0 percent) by Ronnel (P>.10) (Table 2). Feed intake was not changed with Ronnel addition. In the last half of the trial, Ronnel had little effect on performance so that for the 137 days, averaged across concentrations, Ronnel improved daily gain by 2.2 percent, improved feed/gain by 2.5 percent and decreased intake by 1.2 percent. Intake tended to decline as Ronnel level increased. The most effective concentration of Ronnel was 64 g per ton with which overall rate of gain and feed efficiency were enhanced by 3.6 and 3.1 percent, respectively.

Carcass characteristics were not altered statistically by Ronnel feeding (Table 3) although with Ronnel feeding tendencies for decreased rib eye area and increased marbling score and federal grade were apparent. Performance response to Ronnel was less than expected based on results cited earlier.

Overall rate of gain and feed efficiency response to added monensin (7.2 and 11.1 percent) were considerably higher than we have obtained previously in four feedlot trials. Monensin reduced feed intake by 9.2 percent the first 56 days and 3.2 percent thereafter, for an overall reduction of 5.5 percent. Statistically, monensin had no effect on carcass characteristics.

Table 3. Carcass characteristics.

	Ronnel				Monensin	
g/ton	0	64	80	96	30	SE
Carcass wt., #	677	687	677	680	693	9.1
Dressing percentage	59.6	59.5	59.1	59.8	59.3	.36
Liver score	.07	0	0	.04	0	.036
Rib eye area						
Sq. in.	13.03	12.91	12.85	12.80	13.30	.187
Sq. in/cwt	1.93	1.88	1.90	1.89	1.93	.026
KHP, %	2.45	2.45	2.30	2.36	2.32	.105
Fat thickness, in.	.44	.48	.42	.42	.42	.018
Marbling	11.14	11.82	11.32	11.57	10.95	.272
Federal grade	11.1	11.5	11.2	11.4	10.9	.23
Cutability	51.01	50.60	51.08	50.94	51.25	.166

Liquid Trace Mineral for Feedlot Steers

**F. N. Owens, D. R. Gill,
J. J. Martin and D. E. Williams**

Story in Brief

Liquid trace mineral (LTM) was fed to growing steers in one metabolism, two feeding and one receiving trials. A slight depression in nutrient digestibilities was observed, and fecal pH was depressed with LTM feeding. In the feeding trials, daily gain was improved by 11 percent and feed efficiency by 10 percent during the first 56 days, but by the end of the trials (129 and 154 days) the remaining advantages were only 0.7 and 2.2 percent. In a 45-day trial with newly received steers, feed efficiency was slightly increased (7.5 percent) by LTM.

Introduction

Liquid trace mineral (LTM), a product of mineral digestion by autotrophic bacteria marketed by Delst Chemical Company, Anaheim, California, is frequently used as a trace mineral supplement. It is fed at 1.5 lb per ton of ration to feedlot cattle. It contains iron, magnesium, manganese and sulfur and may serve as a fermentation stimulant. It is available as a watery, highly corrosive liquid or dried onto alfalfa meal. As a fluid (25 percent dry matter), it has a pH of 2.6 and 22 percent ash. It will readily digest concrete.

Results reported elsewhere in this publication indicated that LTM increased turnover rate of ruminal liquids and solids. Mies (1978) reported detrimental effects of LTM supplementation for finishing steers. These trials were conducted to determine potential effects of LTM on feedlot performance and steer metabolism.

Materials and Methods

Digestion Trial

Four 770 lb steers were fed a 56 percent rolled corn, 13 percent cottonseed hull, 5 percent alfalfa, 19 percent soybean meal, 4.5 percent molasses ration with or without 0.075 percent added LTM. Urine and feces were collected the final five days of each 14-day period. Steers were switched to opposite treatments for the next 14 days and again collected.

Feeding Trial 1

Twenty-seven 674 lb steers, six or seven per pen, were fed a rolled corn, high concentrate ration for 154 days (Table 1) with or without 0.075 percent LTM. No antibiotics or implants were used. Rate of gain, feed efficiency and carcass characteristics were monitored.

Feeding Trial 2

Fifty-five 662 lb steers, seven per pen, were fed for 129 days the same rolled corn, high concentrate ration as in trial 1 with or without 0.075 percent LTM for 129 days. No antibiotics or implants were used.

Receiving Trial

One hundred-twenty 350 lb steers, ten per pen, were fed the Purina Receiving Ration with or without 0.075 percent added LTM for 45 days. Steer health and performance were recorded for a total of 60 days.

Results and Discussion

Metabolism trial results are presented in Table 2. Fecal pH decreased slightly and fecal dry matter increased slightly with LTM feeding. Urine output increased by 26 percent with LTM. Digestibility of dry matter and protein decreased slightly with LTM addition; however, nitrogen retention was unchanged with LTM feeding. The slight decrease in digestibility matches that observed last year for LTM in a buffer trial (Thornton *et al.*, 1978).

Results from both feeding trials are presented in Table 3. For the total trials, LTM had little influence on rate of gain (+0.7 percent) or efficiency of feed use (+2.2 percent). Over the first two months of each feeding trial, however, rate of gain was increased an average of 11 percent and efficiency of feed use by 10 percent. This suggests that LTM may have a favorable short term effect on steer performance. Of the carcass characteristics measured, incidence and severity of liver abscesses tended to increase with LTM feeding.

In the 45-day trial with receiving cattle (Table 4), feed efficiency again was increased slightly (7.5 percent) by LTM feeding. Factors responsible for these consistent short-term benefits of LTM deserve further attention despite inconsistent results of longer trials.

Table 1. Ration composition, dry matter basis.

Item	%
Corn, rolled	73.8
Cottonseed hulls	15.0
Alfalfa meal	4.0
Molasses, cane	4.0
Cottonseed meal	4.5
Limestone	.75
Urea	.5
Dicalcium phosphate	.15
Salt	.3
Vitamin A[a]	.015
Composition	
Crude protein	11.8
NE_g, kcal/g	1.24

[a]30,000 IU/g.

Table 2. Nitrogen balance results.

	Treatment	
Item	Control	LTM
Steers, no.	4	4
Feed intake, kg/day	6.50	6.43
Feces pH	6.14	5.99
Fecal dry matter, %	26.53	28.08
Urine, L/day	8.66	10.87
Digestibility, %		
Dry matter	75.5	74.1
Nitrogen	70.2	69.6
N retention, g/day	36.5	36.1

Table 3. LTM feeding trial results.

Item	First trial Ration		Second trial Ration	
	Control	LTM	Control	LTM
Steers, no.	13	14	27	28
Pens, no.	2	2	4	4
Daily gain				
0-56	3.03	3.44	3.67[a]	3.99[b]
56-end	2.47	2.23	2.60	2.43
0-end	2.67	2.67	3.06	3.10
Daily feed				
0-56	23.3	23.8	23.2	22.5
56-end	24.9	23.4	25.2	25.5
0-end	24.3	23.6	24.4	24.2
Feed/gain				
0-56	7.95	7.06	6.32	5.65
56-end	10.08	10.49	9.81	10.53
0-end	9.07	8.83	7.97	7.84
Fecal pH	- - -	- - -	5.75	5.53
Carcass characteristics				
Dressing, %	62.0	62.6	58.2	58.3
Liver abscess				
Incidence, %	15.4	21.4	23.2	33.3
Severity	.15	.29	.31	.67
Quality grade	12.7	12.5	10.8	10.6
Yield grade	3.5	3.3	- - -	- - -

[ab]Means within a trial with different superscripts differ statistically (P<.05).

Table 4. LTM for receiving cattle.

Item	Treatment	
	Control	LTM
Steers, no.	60	59
Weight, initial	352	348
Daily gain, lb		
0-45	2.41	2.49
0-60	2.12	2.09
Daily feed, lb		
0-45	15.1	14.4
0-60	15.9	15.3
Feed/gain		
0-45	6.29	5.82
0-60	7.53	7.33
Medical cost, $/steer	1.93	1.78

Literature Cited

Mies, W. L. 1978. Texas Tech Beef Research Report, p. 51.

Thornton, J. H., F. N. Owens, R. W. Fent and K. Poling. 1978. Okla. Agr. Exp. Sta. Res. Rep. MP-103:72.

NUTRITION — COW-CALF and STOCKER

Slow-Release-Urea and Energy Levels for Cattle Fed Low Quality Roughage

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Story in Brief

A new slow-release-urea compound (SRU) was compared to natural protein and prilled urea in winter supplements for grazing dry, pregnant Hereford cows and in drylot with crossbred heifers fed mature fescue hay. Slow release urea produced lower ($P<.05$) rumen ammonia levels in the grazing cows than urea and was more acceptable ($P<.05$). However, SRU did not improve cow performance and only slightly improved heifer performance over that seen with urea. Urea was poorly utilized by both cows grazing winter range grass and the heifers in drylot. Increasing the level of energy in supplements for the grazing cows improved performance of urea and SRU supplements but not with all natural protein supplements.

Introduction

The rapid breakdown of urea to ammonia in the rumen is the reason that toxicity sometimes occurs when urea is fed. If the ration is mostly roughage, the rapid breakdown of urea may be a further disadvantage since fermentable energy needed by the bacteria for protein synthesis will likely not be adequate during the short time period in which urea remains in the rumen. Slowing the rate at which urea is broken down in the rumen would reduce problems with toxicity and could enhance the utilization of urea for bacterial protein synthesis.

Development of a coated, slow-release-urea (SRU) by Nipak Corporation has made possible the evaluation of sustained ammonia release with beef cattle grazing low quality roughage. Previous work at this station (Lusby *et al.*, 1977; Owens *et al.*, 1978) has shown SRU to be more palatable and less toxic than prilled urea. However metabolism studies (Mizwicki *et al.*, 1978) and range cow trials (Forero *et al.*, 1978) have failed to show a consistent benefit of slow ammonia release over typical daily feeding of prilled urea.

The objectives of this research were to further evaluate SRU with dry, pregnant Hereford cows wintered on native tallgrass range and with growing crossbred heifers maintained in drylot.

Materials and Methods

Cow trial

Eighty-eight dry, pregnant, mature cows were used in a wintering trial to compare soybean meal, SRU and urea as protein sources for range cows. The trial was conducted at the Lake Carl Blackwell Range near Stillwater with little bluestem (*Andropo-*

[1]Animal Science Department, Oklahoma State University
[2]Kerr Foundation, Poteau, Oklahoma.

Table 1. Supplement compositions, trial 3[a].

Protein source % crude protein		Soybean meal			Urea		Slow release urea		
Ingredient (%)	IRN	15	20	40	20	40	20	40	70
Corn, ground	4-02-915	61	49		76.8	53.3	77	52.6	33.0
Cottonseed hulls	0-01-599	4	6		5.2		5.2		
Soybean meal	5-04-604	20	33	87.5		21		19.9	33.0
Alfalfa hay, ground	1-99-118	6	6	8	6	6	5	6	
Molasses, cane	4-04-696	5	5	2.5	5	6	5	6	5
Sodium sulfate	6-04-292	2	1	2	1.1	2.3	1.2	2.3	3.5
Trace mineral mix		.05	.05	.05	.05	.05	.05	.05	.1
KCl		2	0		1.6	2.4	1.5	2.4	4.1
Urea					4.3	8.9			
Slow release urea							5.2	10.7	22.0

[a]Phosphorus offered free choice in 6 mineral feeders containing a 1:1 mixture of salt:dicalcium phosphate.

gon scoparious), big bluestem (*Andropogon gerardi*), Indian grass (*Sorghastrum nutans*) and switch grass (*Panicum virgatum*) as the principal grasses present.

Each protein source (Table 1) was fed at two levels of energy (2 lb of 40 percent crude protein/day or 4 lb of 20 percent crude protein/day). Urea or SRU supplied 62.5 percent of the crude protein in urea-containing supplements. In addition a negative control consisting of 2 lb/hd/day of 15 percent natural protein and a very high protein supplement with 70 percent crude protein, 75 percent of the crude protein from SRU (1.3 lb/day), were fed. All supplements were fed in meal form.

All cows grazed a common pasture and were gathered once daily 6 days/week at 8 a.m. for individual feeding of their supplements. Supplements were offered for 1 hr in covered stalls with refusals recorded daily. Cow weights were taken after overnight withdrawal from feed and water. Rumen fluid for ammonia analysis was taken from each cow at 1 hr and 4 hr post supplement feeding once during January.

The trial period was from December 5, 1977 to March 15, 1978. Snow partially or completely covered the ground for 47 days in January and February. As a result, 15 lb/hd/day prairie hay was fed to all cows in 16 days.

Heifer trial

This study was conducted at the Kerr Foundation, Inc. at Poteau in eastern Oklahoma. Fifty-six 8-9-month-old crossbred heifers were allotted by breed and weight to four supplemental protein treatments: 2/lb/hd/day of 20 percent natural protein (negative control), 2 lb/hd/day of 40 percent natural protein (positive control), 2 lb/hd/day of 40 percent crude protein equivalent (62 percent of crude protein from coated urea), or 2 lb/hd/day of 40 percent crude protein equivalent (62 percent of crude protein from urea). Supplement compositions are shown in Table 2.

Each treatment was replicated three times with replications being heavy, medium and light weight heifers. Medium and light replications (five heifers each) and the heavy replication (four heifers each) were randomly assigned to pens of about 16 feet x 60 feet in size with about a third of each pen covered by a roof. Supplements were offered once daily in feed bunks. Mature fescue hay 8.6 percent crude protein was fed as the roughage source *ad libitum* in portable hay managers in each pen. Hay refusals were weighed back once each week.

Heifers were weighed initially, finally and at 28-day intervals after overnight shrink away from feed and water. All supplements were initially fed as 3/8 inch pellets. However, pelleting resulted in heavy damage to the coating of the coated urea and the coated urea supplement was fed in meal form for the last 56 days of the experiments.

Table 2. Supplement compositions, trial 4.

Protein source % crude protein Ingredient %	20%	40%	40%	40%
Soybean meal	33.0	87.5	21.0	19.9
Alfalfa hay	6.0	8.0	6.0	6.0
Cane molasses	5.0	2.5	6.0	6.0
Sodium sulfate	1.0	2.0	2.3	2.3
Ground corn	49.0		53.3	52.6
Cottonseed hulls	6.0			
Urea			8.9	
Coated urea				10.7
Potassium chloride			2.5	2.4
Trace mineral mix	.05	.05	.05	.05

Table 3. Slow release urea trial, individually fed pregnant cows, 1977-78, OSU.

Protein source	**Soybean meal**			**Urea**		**Slow release urea**			**Prob.**
lb supp/day	**2**	**4**	**2**	**4**	**2**	**4**	**2**	**1.3**	
% C.P.*	**15**	**20**	**40**	**20**	**40**	**20**	**40**	**60**	
NH_3, 1 hr (Mg%)	1.8^{b}	5.0^{b}	6.2^{b}	25.9^{a}	26.1^{a}	4.8^{b}	4.9^{b}	5.6^{b}	.001
NH_3, 4 hr (Mg%)	0.5^{e}	3.0^{d}	4.4^{d}	8.8^{b}	14.0^{a}	3.3^{d}	5.6^{cd}	7.3^{bc}	.001
NH_3 decrease (1-4 hr)	-1.3^{c}	-2.0^{c}	-1.7^{c}	-17.1^{a}	-12.1^{b}	-1.5^{c}	$+0.7^{c}$	$+1.7^{c}$	.001
Cow wt change, lb (Dec-Mar)	-68.8^{ab}	-45.0^{a}	-42.7^{a}	-65.9^{ab}	-93.4^{bc}	-75.2^{abc}	-93.1^{bc}	-102.2^{bc}	.001
% supp consumed	99.9^{a}	99.5^{ab}	99.4^{ab}	94.2^{c}	97.2^{b}	99.8^{ab}	99.7^{ab}	97.3^{ab}	.001
Cows/trt, NH_3 data	11	11	10	11	11	10	11	11	
Cows/trt/wt change and supp intake	10	10	9	11	11	10	10	10	

*62.5% of crude protein equivalent from urea in all NPN supplements except SRU with 70% crude protein in which case SRU provided 75% of the crude protein equivalent.

[abcde]Means on a line with the same superscript letter do not differ (P<.05). (Duncans Test).

Results and Discussion

Cow trial

Weight losses for all groups (Table 3) were greater than anticipated due to the unusually severe winter encountered. Cows fed the negative control lost more weight than those fed an isocaloric amount of 40 percent natural protein supplement. This difference approached significance and undoubtedly would have been greater in a "normal" winter. Level of energy did not affect weight losses of cows fed natural protein. Previous work at OSU (Forero, *et al.*, unpublished; Lusby *et al.*, 1976) has shown that cows will reduce forage consumption when supplemental energy is increased. Cow weight losses suggest that urea was poorly utilized in either prilled or SRU form. Increasing the energy level of urea and SRU supplements improved performance in contrast to a lack of energy response seen with natural protein. It should be noted, however, that at best, performance of cows fed urea or SRU was about the same as the negative control. Cows fed 2 lb of 40 percent supplement with urea or SRU lost more ($P<.05$) weight than cows fed 2 lb of 40 percent natural protein supplement.

The 70 percent protein supplement with 75 percent of the crude protein from SRU was fed to evaluate the effect of feeding a slow-release ammonia source as the primary nitrogen supply to the rumen. Apparently nitrogen in the form of ammonia alone was insufficient to meet ruminal protein needs, since this group lost more weight than any other groups.

The SRU was effective in providing a lower level of ammonia in the rumen than was prilled urea (Table 3). Ruminal ammonia levels with SRU were lower ($P<.05$) at both 1 and 4 hr post-feeding than with urea, in agreement with Forero *et al.* (1978). Ammonia levels with all SRU supplements were similar to those produced by natural protein.

Feeding the higher energy level with urea resulted in a significantly faster fall in rumen ammonia between 1 and 4 hr post-feeding, suggesting that higher available energy may have increased the incorporation of ammonia into microbial protein. Increased energy also tended to be associated with faster declines in ruminal ammonia between 1 and 4 hr with SRU, although to a lesser degree than with urea.

Supplements with SRU were more palatable than urea supplements ($P<.05$). More refusals of urea supplements were noted toward the end of the trial suggesting that cows can "sense" urea levels and alter intake accordingly. Similar declines in urea intake were also noted by Forero *et al.* (1978).

Heifer trial

The pelleting process resulted in heavy damage to the coated urea fed the first 28 days of the trial. Therefore, only the last 56 days of the trial evaluated the effects of slow release of rumen ammonia on heifer performance. Although no supplement refusals were noted, heifers required much of the day to consume coated urea when pelleted and the urea supplement, especially toward the end of the trial.

Average daily gains (ADG) for the last 56 days of the study (Table 4) showed that heifers fed the positive control tended to gain the fastest while urea-fed heifers had the poorest gains. Gains for SRU-fed heifers were intermediate between the negative and positive controls.

Hay intakes were similar throughout the trial although heifers fed the 40 percent natural protein and SRU supplements tended to eat more hay than heifers fed the negative control or urea. Although differences in feed efficiency between treatments were large, the differences were not statistically significant ($P<.3$). Pens were the experimental unit for hay intake and feed efficiency allowing only 3 degrees of freedom for each treatment.

Table 4. Heifer gain, hay intake and efficiency for 84 and 56 days, trial 4.

Item	Natural 20% CP	Natural 40% CP	Coated Urea 40% CPE	Urea 40% CPE	Prob.
No. heifers	14	14	14	14	
84 days					
ADG, lb	.65	.82	.67	.61	.12
Hay intake, lb	13.0	13.2	13.7	13.0	.34
Lb hay/lb gain	20.4	16.2	20.6	21.7	.27
56 days					
ADG, lb	.45	.63	.55	.36	.08
Hay intake, lb	14.0	14.2	14.7	14.0	.54
Lb hay/lb gain	32.3	25.8	27.9	45.1	.31

Conversion of hay to gain (last 56 days) was similar between the positive control and coated urea (25.8 vs 27.9 lb hay/lb gain). Heifers fed coated urea showed a 38 percent improvement in conversion of hay to gain over heifers fed urea. These differences in feed efficiency suggest that the digestibility of the hay was improved by the positive control and coated urea.

These data again show that urea was poorly utilized as a nitrogen source for cattle fed roughage. Although SRU tended to be intermediate between soybean meal and urea, differences were too small to make any conclusive statement.

The two studies reported along with the previous work with SRU at this station show that slowing ammonia release alone may not be sufficient to achieve satisfactory utilization of urea. It is probable that the rumen microbes require amino acids, certain volatile fatty acids and other protein precursors as well as a constant ammonia supply. The coating process used to prepare SRU did, however, greatly reduce the possibility of toxicity and did improve the acceptability of urea-containing supplements.

Literature Cited

Forero, O., 1978, Research report MP-103, Oklahoma Ag. Exp. Sta. pp 25-30.

Lusby, K. S., 1976, J. Anim. Sci, 43:543.

Lusby, K. S., 1978, 69th Annual Meeting American Society of Animal Science, Madison, Wisconsin. p 246.

Mizwicki, K. L., 1978, Research report MP-103, Okla. Ag Exp. Sta. pp 22-24.

Owens, F. N., 1978, (unpublished).

Effect of Monensin on Weight Gain and Forage Intake by Replacement Heifers on Native Range

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Story in Brief

A trial consisting of a grazing period on dormant native range for 96 days and on lush forage for 133 days was conducted to evaluate the effect of monensin on weight gain and forage intake by Angus x Hereford replacement heifers. During the dormant forage portion of the trial, heifers were fed a 30 percent crude protein soybean meal supplement with 0 or 200 mg of monensin/hd/day. During the lush forage portion of the trial, heifers were fed 1 lb/hd/day of a carrier containing 0 or 200 mg/lb monensin. Relative forage intake was measured in both portions of the trial.

Weight gains and forage intakes were similar when 200 mg monensin was fed as compared to the controls.

Introduction

Rumensin[1] (monensin sodium) is a feed additive marketed to improve feed efficiency of feedlot cattle. Feeding rumensin to feedlot cattle has little effect on weight gain; however, rumensin is reported to increase weight gains of stocker cattle and has been cleared by the FDA for feeding to stockers weighing in excess of 400 lb.

The objective of this study was to determine the effect of monensin on (1) weight gain (2) forage intake and (3) reproductive performance of heifers grazed on native range forage.

Materials and Methods

One hundred Angus x Hereford heifers were randomly allotted to either a control (0 monensin) or monensin (200 mg/hd daily) treatment group.

The trial consisted of two phases. The first phase of the trial involved a 96-day period (January 30 - May 5) during which the heifers were maintained on dormant native range forage. The second phase of the trial involved 133 days (May 5- September 15) during which the heifers were maintained on lush growing native range forage.

During the dormant forage phase of the experiment, heifers were group fed 4 lb/hd/day of a 30 percent all natural crude protein supplement (Table 1). Monensin was incorporated into the supplement and group fed to heifers on a daily basis.

During the lush forage phase of the experiment, heifers received 1 lb/hd/day of a corn-based carrier (Table 2) containing either 0 or 200 mg/lb of mononsin.

The heifers were pasture mated to Hereford bulls during a 90-day breeding season which began January 10.

Heifers were weighed at approximately 28-day intervals and at that time pastures and bulls were rotated to minimize pasture, location and sire effects.

Relative forage intake by heifers was estimated in March and May using chromic oxide (16 gm/hd/day) as an external indicator. Chromic oxide was individually fed with one-half the daily allocation of supplement at 8 a.m. and 4 p.m. during the seven-day preliminary and five-day fecal collection periods. Fecal grab samples were dried at 60C and analyzed for chromium content.

[1]Elanco, Division of Eli Lilly and Company, Indianapolis, Indiana.

Table 1. Composition of protein supplement fed during the dormant forage period.[1]

Item	%
Cottonseed meal	31.0
Wheat	28.0
Alfalfa	10.0
Milo	20.0
Deflourinated phosphate	5.0
Molasses	5.0
Potassuim chloride	1.0

[1]Monensin was incorporated at the rate of 50 mg/lb in the supplement fed to monensin treated heifers.

Table 2. Composition of carrier supplement fed during the lush forage period.[1]

Item	%
Corn, yellow	85
Dehydrated alfalfa meal	10
Molasses	5

[1]Monensin was incorporated at the rate of 200 mg/lb in the supplement fed to monensin treated heifers.

On July 20, heifers received their respective supplements and were allowed to graze for approximately three hrs. Rumen contents were then sampled for VFA analysis from ten heifers randomly selected from each treatment group.

Heart girth and height measurements were taken at the beginning and end of the trial as further indicators of growth. Heart girth was measured directly. Height was defined as the distance from the hip to the floor and was estimated from measurements of a 2 x 2 slide taken of each heifer behind a grid.

Since the heifers had not completed calving at the time of preparation of this report, percent calf crop, birth weight, calving difficulty scores and postpartum intervals are not reported. These data will be reported at a later date.

Results and Discussion

Performance by heifers grazing dormant winter forage is shown in Table 3. Average daily supplement fed was equal for the two treatment groups. Initial weights were 573 and 568 lb for the control and monensin groups, respectively. During the dormant forage period, weight gains were quite similar for the control and monensin treatment groups (90 and 97 lb, respectively).

Relative forage intake by heifers grazing dormant forage and receiving monensin was about 89 percent of the control group. Although forage intake estimates were quite variable and differences were not statistically significant, this trend was consistent with data previously reported from this station.

Performance by heifers during the lush forage period is shown in Table 4. Initial weights were again quite similar for control and monensin treatment groups (663 and 665 lb, respectively). Weight gain during the lush forage growth period was not significantly influenced by monensin feeding. The average daily gain by heifers during this period was about 1.69 lb/hd/day. Although weight gain responses to monensin feeding have been quite variable in forage grazing trials, the general trend has been toward smaller responses when the level of performance was high such as in this trial.

Table 3. Performance and relative forage intake by heifers during winter supplementation on dormant forage.

Item	Monensin, mg/hd/day 0	200
Heifers, number	50	50
Daily supplement, lb	4.0	4.0
Initial wt, lb	573	568
Final wt, lb	663	665
Wt change, lb	+90	+97
Forage intake, %	100%	89%

Table 4. Performance and relative forage intake by heifers during spring and summer on lush forage.

Item	Monensin, Mg/hd/day 0	200
Heifers, number	46	47
Daily carrier, lb	1.0	1.0
Initial wt, lb	663	665
Final wt, lb	885	892
Wt change, lb	+222	+227
Forage intake 100%	100	116.2

Table 5. Total and molar percentages of volatile fatty acids in rumen fluid.

Item	Monensin, mg/hd/day 0	200
Acetate, molar %	77.13	75.93
Propionate, molar %	14.55	16.39
Butyrate, molar %	8.33	7.63
Total, M/l	59.34	47.13

Table 6. Skeletal measurements of heifers fed 0 vs 200 mg/hd/day of monensin.

Item	Monensin, mg/hd/day 0	200
Initial heart girth, in	58.8	58.6
Increase in heart girth, in	9.2	9.1
Initial height, in	42.0	42.2
Increase in height, in	3.5	3.2

Relative forage intake by heifers grazing lush forage and receiving monensin was 116.5 percent of the control group. Again, estimates of forage intake were quite variable and this difference was not statistically significant.

Total and molar percentages of volatile fatty acids are shown in Table 5. Rumen fluid from heifers fed monensin tended to have less acetate and butyrate and more propionate than that from control heifers. This is a characteristic response to monensin feeding.

Skeletal measurements for the trial are summarized in Table 6. Growth in heart girth circumference and height was quite similar for heifers receiving control and monensin treatments. These observations are in agreement with weight response data.

As previously indicated, data relative to reproductive performance for these heifers will be reported at a later date.

Twenty-Four vs 30-Month-Old Calving with Hereford Heifers

K. S. Lusby,[1] S. O. Enis[1] and R. W. McNew[2]

Story in Brief

Twenty-nine Hereford heifers born in the spring of 1976 and 36 born in the fall of 1975 were managed alike following weaning and were bred in the spring of 1977 to calve at 24- or 30-months of age. Thirty-month-old first calving heifers had 13 percent ($P<.18$) higher conception rates at first breeding and 40 percent higher ($P<.001$) conception rates at rebreeding after calving. Calving difficulty and calf mortality were similar for both groups.

The older heifers were larger at calving but had heavier calves than the younger heifers. Calves of 30-month-old heifers were 45 lb heavier ($P<.001$) at weaning than calves of 24-month-old heifers. Thirty-month old heifers had approximately a 120 lb weight advantage ($P<.001$) at first breeding and maintained that advantage through the weaning of the first calf.

Introduction

Much research has compared the merits of calving heifers for the first time at 24- or 36-months of age. In general, the data have shown that 36-month-old heifers wean heavier calves and rebreed more successfully than two-year-old heifers. Two-year-old heifers will usually require more assistance at delivery but calf losses will be similar since three-year-old heifers will have larger calves than two-year-olds.

In many respects, neither two-year-old nor three-year-old first calving is a feasible alternative for the producer. Many find it very difficult to develop heifers adequately for breeding at 15 months of age and as a result encounter low conception rates at both first breeding and at rebreeding after first calving. Developing heifers for 36-month-old calving is easy but the advanced age at first calving wastes a significant portion of the heifers productive life.

An alternative for those producers calving in both fall and spring would be to breed for first calving at 30 months of age. A great saving in terms of rebreeding rate, productive lifespan and feed could result if an additional six months of development could overcome many of the problems of calving at 24 months of age.

The objectives of this work was to compare the growth and reproductive performance of 24- and 30-month-old first calving heifers and the performance of their calves.

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[2]Associate Professor, Dept. of Statistics.

Experimental Procedure

Data were summarized from 29 Hereford heifers born in the spring of 1976, and 36 heifers born in the fall of 1975. After weaning of the younger group, all heifers were managed alike through the weaning of their first calves in September of 1978. The heifers were used in fly control studies during the summers of 1976 and 1977 and in a wintering study during the winter of 1977 to 78, but were blocked according to age in each case. The study was conducted at the Lake Carl Blackwell experimental range in North Central Oklahoma.

Management of the heifers consisted of wintering on standing tallgrass native range with protein supplementation. Hay was fed on days when snow or ice covered the ground. Summer forage consisted of native range during the summer of 1977 and Midland Bermuda during the summer of 1978.

The breeding season was 60 days in length beginning on May 2, 1977 (first breeding) and May 10, 1978 (rebreeding after 1st calving). In each season, heifers were randomly assigned by age to three Hereford bulls. Pregnancy was determined by rectal palpation about 60 days after bulls were removed.

All calves were weighed, eartagged and tattooed at birth. A calving difficulty score was assigned to each according to a scale of 1-5 where 1 = no difficulty, 2 = some difficulty with no assistance rendered, 3 = light assistance, 4 = hard pull and 5 = caesarean section. No sections were required. Calves were creep fed a mixture of 95 percent oats-5 percent molasses for 60 days before weaning on September 28, 1978.

Results and Discussion

Preweaning performance of calves from the 24- and 30-month-old calving heifers is shown in Table 1. Adjusted weaning weights for 30-month-old heifers were 45 lb heavier ($P<.001$) than for calves of 24-month-olds. Calves of the older heifers were also heavier at birth by 3.4 lb. The number of heifers requiring assistance at delivery was high but similar for both 24- and 30-month-olds (36 and 37 percent respectively). Calving difficulty scores were similar for both groups as were the number of calves failing to survive the first seven days.

Rice (1976) summarizing data comparing two- and three-year-old calving from Miles City, Montana and Fort Robinson, Nebraska showed that while two-year-old heifers required more assistance at birth, calf mortality was not different from that of three-year-olds. The difference was attributed to the fact that three-year-olds had

Table 1. Preweaning performance of first calves from heifers calving at 24- or 30-months of age.

	Heifer age at first calving		
Item	**24 mo.**	**30 mo.**	**Prob.**
Number of calves weaned	16	23	
Calf birth date (day 1=Jan 1)	80	61	P<.001
Calf birth weight, lb	63.7	67.1	P<.11
Calving difficulty score	1.8	1.9	
No. calves dead within 7 days	6	7	
Birth wt of calves assisted	70	72	
Birth wt of calves unassisted	60	64	
Calves assisted at delivery, %	36	37	
Adjusted weaning wt (205 day steer equivalent)	401	446	P<.001

calves weighing 6 to 10 lb more at birth than two-year-olds. Apparently the small increase in birth weight seen with the 30-month-old heifers in this study was enough to offset the larger size of the older heifers at calving.

A breakdown of birth weights by assistance shows that the average birth weight of calves requiring assistance was 10 lb heavier for calves of 24-month-olds and 8 lb heavier for calves of 36-month-olds. These data suggest that difficulty may be encountered when birth weights approach 70 lb in either age of heifers.

Aside from calving difficulty, the greatest problems encountered with 24-month-old calving heifers have been developing them to adequate size to reach puberty at 15 months of age and getting acceptable rebreeding rates after first calving. Conception rate data (Table 2) shows that the older heifers tended to breed more readily at first breeding than did the heifers bred to calve first at 24 months of age (89 percent vs 76 percent).

The older heifers weighed 115 lb more (P<.001) than the younger heifers at the beginning of the first breeding season. Since heifer weight is an important factor in determining the onset of puberty in heifers, breeding first at 21-months to calve at 30-months should improve conception rates at first breeding. This is especially true in times when forage and supplemental feed are not adequate for the rapid growth required for breeding at 15 months of age.

The most striking effect of age at first calving is seen in the rebreeding rates following first calving. Only 42 percent of the 24-month-old heifers rebred during the 60-day breeding season compared to 82 percent of the older heifers.

Harsh weather conditions during the winter of 1977 to 78 (47 days of snow cover) may have reduced overall rebreeding performance from that expected in a more normal winter. However, the rebreeding rates seen here are probably indicative of the consequences of calving at an early age when nutritional or climatic stress is encountered.

Weight change patterns in Table 2 show that both groups of heifers lost about the same amount of weight during the winter and regained about the same amount of weight during the summer when they were lactating. These weight changes suggest that the greatest advantage of calving first at 30 months of age is found in the larger weight and increased development at first breeding which seems to carry on through the weaning of the first calf.

Table 2. Weight changes and conception rates of 24- and 30-month-old heifers through the first calf crop.

	Heifer age at first calving		
Item	24 mo.	30 mo.	Prob.
Heifers weight			
at birth	73	70	
at first breeding (5/2/77)[1]	522	637	P<.001
fall before 1st calving (9/28/77)[2]	726	850	P<.001
30 days before 1st calving			
season (2/1/78)[2]	776	883	P<.001
at 2nd breeding (5/10/78)[3]	668	724	P<.001
at weaning of 1st calf (9/28/78)[3]	784	851	P<.001
Conc. rate after 1st breeding			
season, %	76(22/29)	89(32/36)	P<.18
Conc/ rate after 2nd breeding			
season	42(8/19)	82(22/27)	P<.004

[1]Includes all heifers exposed to bulls.
[2]Includes all heifers pregnant 60 days after breeding season.
[3]Includes only heifers weaning a calf.

These results show that calving Hereford heifers first at 30 months of age improves conception at both first breeding and rebreeding after calving over that seen with calving first at 24-months. Weaning weight of the first calf crop was increased by 45 lb with the older heifers. Calving difficulty and calf mortality were similar with both groups. If forage and feed supplies are adequate, heifers may be properly developed and maintained for calving at 24-months. On the other hand, these results show that many effects of harsh weather and marginal nutrition can be overcome by calving at 30 months of age.

Literature Cited

Rice, L. E., 1976, Proc, OK Cattle Conf, Oklahoma State Univ, Stillwater.

Effect of Potassium on Weight Gains of Steers Wintered on Dormant Native Range[1]

G. W. Horn, P. L. Sims and K. S. Lusby

Story in Brief

Hereford steer calves were wintered on dormant native range and fed protein supplements containing 20 or 40 percent crude protein. The 40 percent crude protein supplements contained all natural protein or coated urea and 1.47 or 3.0 percent potassium (K). Gains of steers fed the coated urea, 3 percent K supplement were similar to those of steers fed the coated urea, 1.47 percent K supplement when averaged across four blocks of pastures.

Introduction

Potassium (K) markedly affects cellular protein synthesis (Lubin and Lubin and Ennis, 1964). In experiments conducted by Rinehart *et al.* (1968), significantly less of the amino acid, leucine, was incorporated into skeletal muscle protein by chicks fed a K-deficient diet.

Weight gains of steers, fed rations in which supplemental soybean meal was withdrawn during the latter part of the finishing period, were slightly increased by supplemental K (Preston *et al.*, 1974 and Preston and Cahill, 1974).

Recent studies by Karn and Clanton (1976 and 1977) have shown that weight gains of steer calves wintered on dry, native range were increased by the addition of K to urea-containing protein supplements. The object of this study was to obtain additional information relative to the effect of K, when added to urea-containing supplements, on weight gains of steers wintered on dry, native range.

[1]In cooperation with USDA, Science and Education Administration, Agricultural Research, Southern Region.

Experimental Procedure

The trial was conducted during a 99-day period, December 19, 1977 to March 28, 1978, at the Southern Plains Experimental Range, Woodward, Oklahoma.

Ninety-six (96) fall-weaned Hereford steer calves (mean initial weight of 538 lb) were randomly allotted to four treatments of six steers per treatment in a randomized complete block design with four blocks. Steer treatment groups were rotated among the four pastures of each block at two-week intervals throughout the trial. The steers had been vaccinated for blackleg, malignant edema, IBR, PI_3, leptospirosis, treated for ear ticks and implanted with 15 mg diethylstilbestrol.

Steers were group fed 1.75 lb/head/day,[2] six days per week, of a (1) 20 percent crude protein, all-natural supplement (negative control), (2) 40 percent crude protein, all-natural supplement (positive control), (3) 40 percent crude protein, coated urea[3]-containing supplement (coated urea), or (4) 40 percent crude protein, coated urea[3]-containing supplement plus additional K (coated urea plus K). Composition of the supplements is shown in Table 1.

Coated urea supplied 50 percent of the total crude protein equivalent of the urea-containing supplements. The negative control and coated urea supplements were formulated to contain the same amount of K (1.47 percent) as the positive control supplement. The coated urea, plus K supplement contained 3.0 percent K. All supplements contained 1.2 percent phosphorus and were fed in meal form, since the stability of the coated urea to pelleting was unknown at the time the trial was conducted.

Steers were weighed at early morning prior to grazing at approximately 28-day intervals throughout the trial. Initial and final steer weights were means of two consecutive day weights. The steers did not have access to water for approximately 12 hr prior to each weighing.

The data were analyzed by analysis of variance. Differences among planned, two-mean comparisons were tested for significance by the least significant difference procedure.

[2]An equivalent of 1.5 lb/head/day, 7 days per week.
[3]Nipak Chemical Company, Pryor, Oklahoma.

Table 1. Composition[a] of supplements.

	Negative control	Positive control	Coated urea	Coated urea plus K
Corn	43.86	- - -	43.30	39.36
Cottonseed meal	37.86	92.40	34.31	35.17
Soybean meal	- - -	4.40	4.40	4.40
Coated urea[b]	- - -	- - -	9.35	9.35
Cottonseed hulls	10.11	- - -	- - -	- - -
Profos	3.27	.20	3.39	3.40
KC1	1.15	- - -	1.25	4.32
Na_2SO_4	.75	- - -	1.0	1.0
Molasses	3.00	3.00	3.0	3.0
$NE_{maint.}$	81.64	78.19	77.73	74.38
NE_{gain}	51.37	51.37	51.07	48.87
Crude protein	22.2	44.4	44.4	44.4
Ca	1.13	.27	1.17	1.17
P	1.20	1.20	1.20	1.20
K	1.47	1.47	1.47	3.0
S	.39	.40	.44	.44

[a]Percent of ration dry matter except for $NE_{maint.}$ and NE_{gain} which are expressed as Mcal/cwt.
[b]Nipak Chemical Company, Pryor, Oklahoma.

Results and Discussion

Total weight gains or losses of steers during the trial are shown in Table 2. Since the analysis of variance procedure indicated a significant block x treatment interaction ($P<.022$), steer weight gains or losses are shown (1) for each block and (2) averaged across all blocks. The mean square for variation among steers within treatments and blocks (80 degrees of freedom) was used for testing for block x treatment interaction.

Weight gains of steers fed the positive control supplement were greater than those of steers fed the negative control, although this difference varied among blocks from 4.2 to 53.3 lb and was significant ($P<.05$) only for steers of block 2. Gains of steers fed the coated urea supplement in blocks 1 through 4 were decreased by 10.9, 30.8, 25.9 and 9.2 lb, respectively, as compared with gains of steers fed the positive control.

In all blocks except number 4, the inclusion of additional K in the coated urea supplement increased steer gains as compared with steers fed the coated urea supplement which contained 1.47 percent K. The magnitude of the increased gains was very small, however, for steers of blocks 2 and 3.

The primary grass species composition, based on forage production analysis, of the pastures of blocks 1, 2 and 3 is blue grama, sand dropseed, little bluestem, sand bluestem and switchgrass; whereas, that of block 4 is caucasian bluestem, blue grama, sideoats grama and hairy grama. Possible differences in the K content of the grasses may partially account for the observed differences in response to the inclusion of additional K in the coated urea supplement.

Steer weight gains pooled across blocks were about 25 lb greater ($P<.05$) for steers fed the positive versus negative control supplements. Gains of steers fed the coated urea and coated urea plus K supplements were similar and only about 36 percent of those of steers fed the positive control supplement.

Literature Cited

Karn, J. F. and D. C. Clanton. 1976. Proc. Nebraska Beef Cattle Report, p. 17.

Karn, J. F. and D. C. Clanton, 1977. J. Anim. Sci. 45:1426.

Lubin, M. 1964. Fed. Proc. 23:994.

Lubin, M. and H. L. Ennis. 1964. Biochem. Biophys. Acta. 80:614.

Preston, R. L., W. B. Kunkle and V. R. Cahill. 1974. Proc. Beef Cattle Res. Rep., Wooster, Ohio. p. 1.

Preston, R. L. and V. R. Cahill. 1974. Proc. Beef Cattle Res. Rep., Wooster, Ohio. p. 7.

Rinehart, K. E., W. R. Featherston and J. C. Rogler. 1968. J. Nutr. 95:627.

Table 2. Mean steer weight gains or losses (pounds) during 99-day trial.

Treatment:	Negative control	Positive control	Coated urea	Coated urea plus K	LSD[a]
Block					
1	5.0	16.7	5.8	18.3	37.9
2	−25.8	27.5[b]	−3.3	0	37.9
3	15.0	19.2	−6.7	−3.3	37.9
4	25.8	55.0	45.8	30.0	37.9
Mean of all 4 blocks:	5.0	29.6[b]	10.4[c]	11.2	19.0

[a]Least significant difference ($P=.05$); calculated from the pooled block x treatment error mean square.
[b]Significantly different from negative control ($P<.05$).
[c]Significantly different from positive control ($P<.05$).

Performance and Economic Comparisons of Alternative Beef Production Systems for Fall-Weaned Calves

**T. L. Mader, G. W. Horn,
O. L. Walker, L. E. Walters,
S. L. Armbruster and W. E. McMurphy**

Story in Brief

Studies were conducted to compare live and carcass weight gains and economic returns of fall-weaned steer calves carried through on different production systems. In one system steers were placed directly in the feedlot. In the other systems steers were carried as stockers on wheat pasture or bermudagrass hay (stocker phase) before grazing small grains-interseeded bermudagrass (SG/B) pastures throughout the summer or being fed to finish in feedlot. Steers from each of the two stocker programs were also grazed to heavier weights on SG/B pastures for 63 days before being finished in feedlot.

Live and carcass weight gains of steers grazed on wheat pasture or fed bermudagrass hay during the stocker phase were 1.16 and .90 lb/day (wheat pasture) and .39 and .16 lb/day (bermudagrass hay). In the finishing phase, performance of steers stockered on wheat pasture was initially greater than that of steers fed bermudagrass hay during the stocker phase. Of all steer groups finished in feedlot, average daily gains of the initial feedlot steers were the lowest; however, their feed efficiencies were the best (6.37 lb feed DM/lb gain).

Enterprise budgets were developed for each beef production system. Steers stockered on wheat pasture and/or grazed 63 days or throughout the summer on SG/B pastures paid all production costs and a residual return to the producer. Grazing steers 63 days on SG/B pastures increased returns \$41.46 and \$34.43 per head for steers from the respective wheat pasture and bermudagrass hay stocker programs. The bermudagrass hay stocker program was not profitable. Break-even analysis indicated that gains of nearly 1 lb per day were needed to pay all non-feed and feed costs of steers carried through the winter on bermudagrass hay. Breakeven daily gains of steers stockered on wheat pasture were 1.3 lb.

Introduction

During the fall of 1976, a project was begun at the Southwestern Livestock and Forage Research Station (El Reno, Oklahoma) to compare cattle performance and economics of some alternative stocker and finishing programs for fall-weaned calves. Data relative to the performance and economics (\$ returned per head) of cattle of the different production systems, during the first year of the project, have been reported (Mader *et al.*, 1978a and 1978b). The results of the second year of the project are reported herein.

Experimental Procedure

Cattle

One-hundred and thirteen (113) fall-weaned Hereford x Angus steer calves were purchased through an order buyer. After being carried through a receiving program of about three weeks, during which the calves grazed native tall grass pastures, the calves were randomly allotted to the treatment groups shown in Figure 1.

Initial Feedlot Group

Twelve steers (four pens of three head/pen) were placed in drylot and fed *ad libitum* a finishing ration of whole shelled corn, cottonseed hulls and supplement. The ration contained 40 percent cottonseed hulls initially, and corn was substituted for the hulls at a rate of about 1 percent per day until the steers were on a ration of 87 percent whole shelled corn, 5 percent cottonseed hulls and 8 percent supplement. The supplement contained 60 percent crude protein on a dry matter basis.

Stocker Phase

Ninety-four (94) of the remaining steers were allotted to two groups of 47 steers per group and were placed on 1) wheat pasture or 2) a dormant bermudagrass pasture and fed bermudagrass hay *ad libitum* from November 9, 1977 to March 29, 1978. Core samples of about one-third of the bales of bermudagrass hay fed were taken weekly for crude protein and *in vitro* dry matter digestibility (IVDMD) determinations.

A mineral mix consisting of 2 parts dicalcium phosphate, 1 part trace-mineralized salt and 5 percent cottonseed meal was fed free choice to each group of steers.

Initial (seven steers) and intermittent slaughter groups (four steers/stocker group) were killed immediately prior to and after the stocker phase so dressing percentage and carcass composition could be measured. Dressing percentages of the initial slaughter group, wheat pasture and bermudagrass hay-fed steers *after* the stocker phase were 49.39 ± .80, 56.53 ± .47 and 48.47 ± 1.01 percent, respectively.

Finishing Phase

At the end of the stocker phase, 40 steers within each of the two stocker groups were randomly assigned to five treatment groups I - V or VI - X (Figure 1). Each treatment group consisted of two pens (replications) of four steers/pen. Steers were fed in their respective treatment groups until it was judged their carcasses would grade low-choice, at which time they were killed at a commercial packing plant.

Groups I and VI were grazed to heavier weights on SG/B pastures from March 29 to May 31, 1978 (63 days) before being finished in drylot. Groups III and VIII were grazed on SG/B pastures and fed complete mixed rations *ad libitum*. Each of the two replications of four steers/replication in treatment groups III and VIII were assigned "paired" replicates from the following groups of steers. One group grazed SG/B pastures and was fed nothing but the mineral mix utilized in the stocker phase (treatment groups II and VII). The second group was placed in drylot and limit-fed (groups IV and IX). The third group was fed *ad libitum* in drylot (groups V and X) the same rations that groups III and VIII were fed on SG/B pastures.

Drylot groups IV and IX were limit-fed daily the same amount of ration that their paired group on SG/B consumed. The amount of ration fed daily to the drylot, limit-fed groups were adjusted weekly. Additional "put-and-take" steers were used in the SG/B pastures that Groups II and VII steers grazed in order to fully utilize the available forage.

The small grains-interseeded (SG/B) pastures were seeded with 50 lb Triumph 64 wheat and 50 lb Bonel rye per acre during the third week of September, 1977, with a John Deere Powr-Till Seeder. Fifty lb of nitrogen was applied per acre in early October and again in February.

All steer weights used to calculate live weight gains were taken after over-night shrinks (usually about 16 hr without feed and water).

Results and Discussion

Stocker Phase

Weight gains of steers during the stocker phase are shown in Table 1. Live and carcass daily weight gains of steers were 1.16 and .90 lb (wheat pasture) and .39 and .16

Table 1. Performance of steers during stocker phase.

Item	Wheat pasture	Bermudagrass hay[c]
Initial live wt, lb	475	482
Final live wt, lb	637[a]	537[b]
ADG (live), lb	1.16[a]	0.39[b]
ADG (carcass), lb	0.90[a]	0.16[b]

[a,b]Means with different lettered superscripts are statistically different (P<.05).

[c]Mean crude protein and TDN were 11.58 ± .41 and 48.50 ± .81 percent, respectively.

Table 2. Performance of steers from two previous stocker programs when grazed on small grains-interseeded bermudagrass pastures and then finished in drylot.

Item	Wheat pasture	Bermudagrass hay
Initial wt, lb	643[a]	539[b]
Final wt, lb	1051	1020
ADG, lb		
SG/B[c]	2.39[a]	1.84[b]
Drylot	3.03	3.12
SG/B and drylot	2.76	2.67
Feed/gain[d]	8.21	7.53

[a,b]Means with different lettered superscripts are statistically different (P<.05).

[c]While grazing small grains-interseeded bermudagrass pastures (63 days).

[d]Pounds feed dry matter per pound of gain (drylot period).

lb (bermudagrass hay-fed steers), respectively. Due to snow and/or ice cover during January and February, bermudagrass hay was fed to steers on wheat pasture for a total of 29 days, which would account for their relatively low gains. The bermudagrass hay fed to steers on dormant bermudagrass pastures was 3.73 percentage units higher in crude protein (11.58 *vs* 7.85) and 4.36 percentage units higher in estimated TDN (48.50 *vs* 44.14) than the hay fed during the first year of the project. The improvement in hay quality increased steer gains markedly from .0 lb the first year to .39 lb the second year.

Finishing Phase

During the first year of the project, feed consumption of steers fed grain on SG/B pastures was high (e.g., approximately 80 percent of their paired, *ad libitum*-fed groups in drylot) and their return (dollars/head) was the lowest. Similar levels of grain consumption by steers fed on SG/B pastures was observed the second year. Therefore, data relative to the steers fed on SG/B pastures and their paired, limit-fed groups in drylot are not included in this report.

Live weight gains and feed efficiencies (drylot only) of steers grazed to heavier weights on SG/B pastures for 63 days after the stocker phase before being finished in drylot are shown in Table 2.

Gains of the bermudagrass hay-fed steers were about 23 percent less than those of wheat pasture steers (1.84 vs 2.39 lb/day) during the 63-day period on SG/B pastures. However, during the subsequent drylot period, daily gains were slightly higher for steers fed bermudagrass hay (3.12 vs 3.03 lb) during the stocker phase.

In situations where steers of similar type and condition such as those at the beginning of this study are carried through stocker programs which effect large differences in gains and fleshiness at the end of the stocker program, it would be anticipated that steers held on the lower plane of nutrition would make compensatory gains during the post-stocker finishing phase. Daily gains and carcass fat content of the wheat pasture steers were .77 lb and 10.1 percent greater than the steers fed bermudagrass hay during the stocker phase. However, compensatory gains, as reflected by increased gains and improved feed efficiencies, were not consistently observed during the finishing phase by steers fed bermudagrass hay during the stocker phase (Tables 2 and 3).

Performance of steers during the finishing phase is shown in Table 3. Daily gains of steers that grazed SG/B pastures throughout the summer were slightly greater (1.51 *vs* 1.46 lb) for steers fed bermudagrass hay during the stocker phase. Gains of steers placed directly in drylot after the stocker phase were greater for steers stockered on wheat pasture (3.67 *vs* 3.16 lb). Steers stockered on wheat pasture consumed about 1.25 lb more feed dry matter per day during the finishing phase than the bermudagrass hay-fed steers. Drylot feed efficiencies of steers stockered on wheat pasture were more variable than, but not statistically different ($P>.05$) from, those of the steers fed bermudagrass hay during the stocker phase.

Carcass characteristics of steers in the finishing phase are shown in Table 4. Steers from the wheat pasture stocker phase had greater rib eye areas and lower yield grades, but marbling scores were lower than carcasses of steers fed bermudagrass hay during the stocker phase. Total days in drylot were less for steers from the wheat pasture stocker phase, however.

Steers that were stockered on wheat pasture and then grazed on SG/B pastures through the summer were slaughtered on September 26, 1978. Although their carcass data are not shown in Table 4, hot carcass weight, dressing percent and yield grade averaged 493 lb, 54.9 percent and 2.58, respectively, while carcass quality grade was between average- and high-good.

Performance and carcass data of the steers that were initially placed in drylot (November 9, 1977) versus that of steers stockered on wheat pasture or bermudagrass hay prior to being finished by feeding *ad libitum* in drylot are shown in Table 5. Live and carcass average daily gains of steers initially placed in the drylot were lower ($P<.05$) than those of either group of steers that was carried through as stockers before being finished in drylot. Feed dry matter consumption of the initial feedlot steers was low for reasons that cannot be explained. However, improved feed efficiencies, expressed as feed required per pound of carcass gain, were observed for the initial feedlot steers.

Table 3. Performance of steers during finishing phase.

Stocker phase:	Wheat pasture			Bermudagrass hay		
Group:	SG/B[e] then drylot	SG/B[f]	Drylot	SG/B[e] then drylot	SG/B[f]	Drylot
Initial wt, lb	643[b]	634[b]	639[b]	539[a]	534[a]	536[a]
Final wt, lb	1051[d]	897[b]	965[c]	1020[cd]	806[a]	1004[cd]
Hot carcass wt, lb	667[b]		603[a]	613[a]		638[ab]
Days fed in drylot	85		89	117		148
Total days in finishing phase	148	180	89	180	180	148
ADG (live), lb	2.76[bc]	1.46[a]	3.67[d]	2.67[b]	1.51[a]	3.16[c]
ADG (carcass), lb	2.05[a]		2.72[b]	1.95[a]		2.55[b]
Feed DM intake, lb	24.85		25.59	23.49		24.43
Feed/gain (live)[g]	8.21		7.00	7.53		7.73
Feed/gain (carcass)[g]			9.41			9.57

[abcd]Means with different lettered superscripts are statistically different ($P<.05$).
[e]Grazed small grains-interseeded bermudagrass pastures 63 days then finished in drylot.
[f]Grazed small grains-interseeded bermudagrass pastures for entire finishing phase.
[g]Pounds feed dry matter per pound gain in drylot.

Table 4. Steer carcass characteristics.

Stocker phase:	Wheat pasture		Bermudagrass hay	
Group:	SG/B[c] then drylot	Drylot	SG/B[c] then drylot	Drylot
Dressing percent	63.57[b]	62.50[b]	60.09[a]	63.51[b]
Fat thickness, in.	.74[ab]	.62[a]	.69[ab]	.83[b]
REA, sq. in.	11.68[b]	11.34[ab]	10.59[a]	11.07[ab]
KPH fat, %	2.31	2.63	2.38	2.19
Yield grade	3.61	3.24	3.63	3.90
Marbling score[d]	14.13[ab]	12.38[a]	15.00[ab]	15.25[b]
Quality grade[e]	10.00	9.00	10.50	10.50

[ab]Means with different lettered superscripts are statistically different (P<.05).
[c]Grazed small grains-interseeded bermudagrass pastures 63 days then finished in drylot.
[d]17 = average modest; 14 = average small; 11 = average slight.
[e]12 = high choice; 10 = low choice; 8 = average good.

Table 5. Performance and carcass data of initial feedlot steers versus steers carried through as stockers before being finished in drylot.

Group:	Initial feedlot	Wheat pasture	Bermudagrass hay
Initial wt, lb	458	639*	536*
Final wt, lb	941	965	1004
Days in stocker program	0	140	140
Days in drylot	194	89	148
Total no. of days	194	229	288
Feed DM intake, lb	15.81	25.59	24.43
ADG (live), lb	2.49	3.67*	3.16*
ADG (carcass), lb	1.87	2.72*	2.55*
Feed/gain (live), lb[a]	6.37	7.00	7.73
Feed/gain (carcass), lb[a]	8.47	9.41	9.57
Hot carcass weight, lb	589	603	638
Dressing percent	62.58	62.50	63.51
Fat thickness, in.	.79	.62*	.83
REA, sq. in.	10.80	11.34	11.07
KPH fat, %	3.63	2.63*	2.19*
Yield grade	3.98	3.24*	3.90
Marbling score[b]	17.33	12.38*	15.25*
Quality grade[c]	11.25	9.00*	10.50

*Significantly different from initial feedlot group (P<.05).
[a]Pounds feed dry matter per pound of gain.
[b]17 = average modest; 14 = average small; 11 = average slight.
[c]12 = high choice; 10 = low choice; 8 = average good.

In general, except for marbling score and quality grade, the carcass characteristics of steers stockered on wheat pasture before being finished in drylot were the most desirable. Carcass characteristics of steers fed bermudagrass hay during the stocker phase and the initial feedlot steers were similar; quality grade of carcasses of both groups was above low-choice.

Enterprise Budget Analysis

The Oklahoma State University Budget Generator was used to analyze the economic potential of the stocker and finishing programs. Each enterprise budget was developed from management and feeding data for steers within the respective treatment groups during this study. In order to eliminate differences in costs not related to treatment, the average initial weight of all steers was adjusted to 475 lb. Similarly, the average initial weight of all steers entering the finishing phase was adjusted, within stocker groups, to a common weight. Steer gains and feed efficiencies used in the budgets are nearly identical to the actual observed values. One exception is the average daily gains for the 63-day, post-stocker period of 1) steers grazed on SG/B prior to being finished in drylot, and 2) steers that remained on pasture all summer. These were averaged, within the previous stocker treatment groups, since they were managed similarly during the 63-day, post-stocker period.

Feeder and fed steer prices utilized in the budgets were obtained from modifications of projected annual averages developed by area extension farm management specialists. Adjustments for variation in cattle prices for the months steers were bought and sold were made by multiplying the annual average price by 10-year-average ratios, which reflect the seasonal variation in the cattle market during the past 10 years.

After the best estimate of operating inputs, machinery and equipment requirements, labor requirements and production receipts have been determined for each production system and entered into the computerized budget program, an analysis of the production system is printed out. Production costs are broken down into operating, capital, ownership, labor and pasture categories; thus, returns to land, labor, capital, machinery, overhead, risk and management are obtained. The breakdown of cost and returns enables producers to make decisions based upon their own production resource situation.

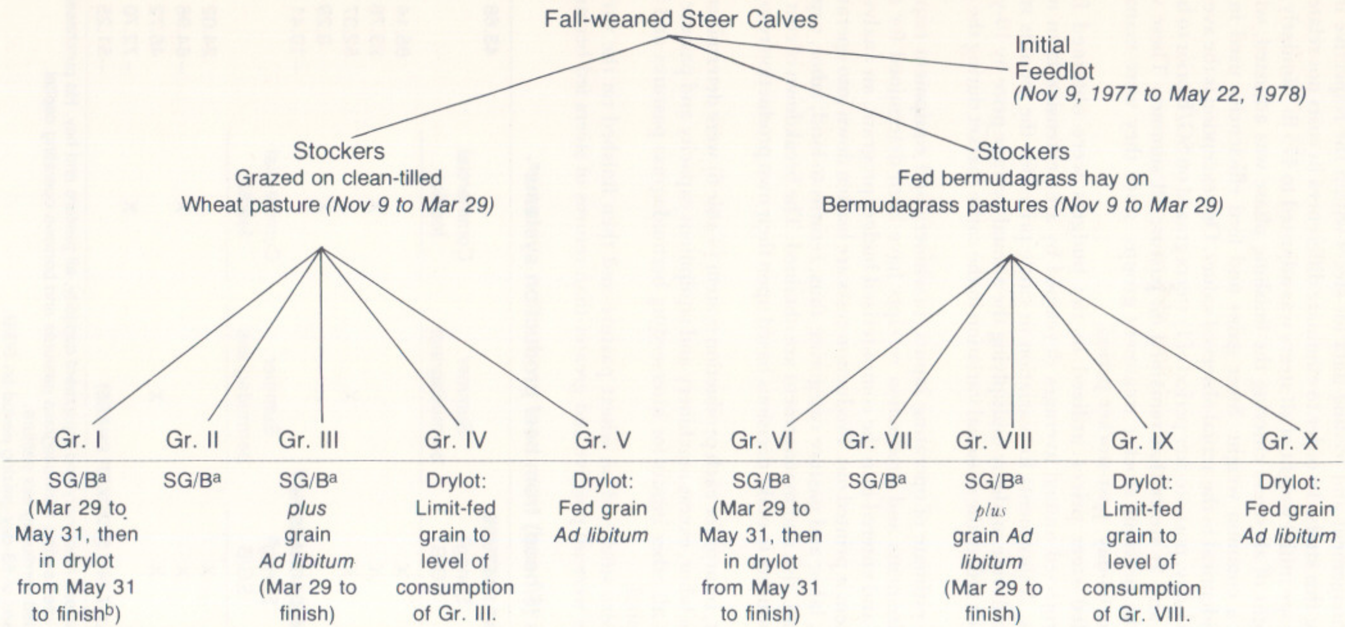
For this report, returns for each production system (Table 6) were determined for a producer who has labor, excess machinery and equipment capacity and pasture and hay. He purchases all other inputs for interseeding bermudagrass pastures and borrows operating capital.

Returns of steers stockered on wheat pasture and then finished on the various production systems were all positive and greater than returns of steers fed bermuda-

Table 6. Returns ($/head) from beef production systems[a].

Stocker phase: WHEAT PASTURE				43.68
Finishing system	Spring[b] SG/B	Summer bermudagrass	Commercial feedlot	
I[c]	X			85.14
I[d]	X		X	23.76
II	X	X		52.37
V			X	8.29
Stocker Phase: BERMUDAGRASS HAY				−10.41
Finishing system	Spring[b] SG/B	Summer bermudagrass	Commercial feedlot	
VI[c]	X			24.02
VI[d]	X		X	−64.96
VII	X	X		46.72
X			X	−72.70
COMMERICAL FEEDLOT (NO STOCKER PHASE)				−51.25

[a]Producer has labor, excess machinery and equipment capacity, all pasture and hay. He purchases the other inputs, pays for interseeding bermudagrass pastures and borrows operating capital.
[b]Small grains-interseeded bermudagrass pasture.
[c]Feeder cattle sold at end of 63-day grazing period on SG/B.
[d]Fed cattle sold at end of feedlot period.



[a]Small grains-interseed bermudagrass pastures.
[b]Carcass quality of low choice.

Figure 1. Steer treatment groups.

Table 7. Non-feed and feed costs ($/head/day) for stocker programs.

Production system	Non-feed[a]	Feed[a]	Total	Selling price $/cwt	Breakeven ADG, lb
Wheat pasture	.52	.39	.91	69.50	1.31
SG/B-63 days	.49	.41	.90	66.40	1.36
SG/B-entire summer	.53	.32	.85	56.50	1.51
Bermudagrass hay	.39	.34	.73	73.50	.99
SG/B-63 days	.40	.34	.74	70.50	1.05
SG/B-entire summer	.45	.27	.72	61.80	1.17

[a]Includes all costs used to determine returns of production systems in Table 6. In addition, all livestock, equipment and machinery labor is included in non-feed costs and all bermudagrass hay, wheat and native pasture is included in feed costs.

grass hay during the stocker phase and their respective finishing systems. Returns of steers stockered on wheat pasture were $43.68, $85.14 and $52.37 per head at the end of the stocker phase and after grazing SG/B pastures for 63 days or throughout the summer, respectively. These all-forage production systems also produced the greatest returns the first year of the project.

Returns of steers fed bermudagrass hay during the stocker phase were $−10.41 per head. Grazing steers fed bermudagrass hay during the stocker phase on SG/B pastures for 63 days or through the summer increased returns $34.43 and $57.13 per head over the stocker phase. Steers fed bermudagrass hay during the stocker phase and then 1) grazed on SG/B pastures prior to being finished in the feedlot or 2) placed directly in the feedlot lost $64.96 and $72.70 per head, respectively. These negative returns can be attributed to the low gains during the stocker phase and to the failure of the producer to obtain returns to management and labor when cattle go to the commercial feedlot.

Returns were the best for production systems where the producer managed the steers himself by utilizing his own facilities during the entire production period. Returns were decreased by relinquishing management control of the steers, and thereby having to pay for all incurred management and labor cost. This was the case when the fall-weaned calves were placed directly into the feedlot. Returns were $−51.25 per head partially because the producer was unable to sell any of his own resources in the commercial feedlot.

Break-even gains, selling price per cwt, non-feed and feed costs are shown in Table 7 for the different all-forage beef production systems. Non-feed and feed costs includes all those that were used to determine the returns in Table 6. In addition, all livestock, equipment and machinery labor required in the care of steers was included in non-feed costs, and all bermudagrass hay, wheat and native pasture was included in feed costs.

Mean non-feed costs were 1.38- and 1.31-fold greater than feed cost for steers of the wheat pasture and bermudagrass hay production systems, respectively. Grazing steers on SG/B pastures for 63 days decreased daily non-feed cost slightly with feed cost being increased slightly (wheat pasture) or remaining the same (bermudagrass hay). Total daily costs were decreased by grazing steers throughout the summer on SG/B pastures; however, non-feed costs were substantially greater than that of steers grazed on SG/B pastures for 63 days. The increase in non-feed cost is largely attributed to the decline in selling price of the heavier steers and is reflected in the increased average daily gains needed to breakeven.

Literature Cited

Mader, T. L., G. W. Horn, S. L. Armbruster, L. E. Walters, D. T. Hoskins, F. P. Horn, W. E. McMurphy and O. L. Walker. 1978a. Okla. Agr. Exper. Sta. Res. Rep. MP-103, p. 1.

Mader, T. L., G. W. Horn, O. L. Walker, S. L. Armbruster, L. E. Walters, D. T. Hoskins and W. E. McMurphy. 1978b. Okla. Agr. Exper. Sta. Res. Rep. P-768. p. 47.

NUTRITION — FORAGE EVALUATION

Steer Weight Gains on Midland, Hardie, Oklan and SS-16 Bermudagrass Pastures

G. W. Horn and W. E. McMurphy

Story in Brief

Daily weight gains of steers, stocking rate and total beef production per acre were evaluated on four varieties (Midland, Hardie, Oklan and SS-16) of bermudagrass pastures during the 1977 and 1978 bermudagrass growing seasons. Total season average daily gains of steers were good and ranged from 1.45 to 1.80 lb (1977) and 1.72 to 2.09 lb (1978). Total gains per acre on Hardie bermudagrass were about 135 lb greater (552 *vs* 417 lb) than those of the other varieties (1977), and about 80 lb greater (487 *vs* 407 lb) than those of Midland and SS-16 bermudagrass (1978). Total gains per acre on Oklan bermudagrass were the lowest for both growing seasons which was a reflection of some stand loss from winter killing.

The steer gains emphasize the importance of pasture management in maintaining an immature, growing forage. Marked changes in carrying capacity (total steer days/acre) observed within varieties for different periods of the bermudagrass growing season indicate that adjustment of stocking rate is a critical management problem in bermudagrass stocker programs.

Introduction

Bermudagrass is often criticized as not supporting acceptable weight gains of stocker cattle throughout the bermudagrass growing season. Over 750 and 625 lb of stocker gain per acre for yearling steers and spring-weaned calves, respectively, on Coastal bermudagrass at the North Louisiana Hill Farm Experiment Station (Homer, Louisiana) have been reported by Oliver (1976). We report, herein, results of steer grazing trials conducted during the bermudagrass growing seasons of 1977 and 1978 on pastures of four bermudagrass varieties.

Experimental Procedure

The trials were conducted at the Agronomy Research Station, Perkins, Oklahoma. Two blocks of pastures, each containing one pasture of the hybrid bermudagrass varieties Midland, Hardie, Oklan and SS-16 (an unreleased experimental strain), were used in a randomized complete block design. The soils are the Dougherty, Konowa and Teller fine sandy loams (Arenic Haplustalfs, Ultic Haplustalfs and Udic Argiustolls). Soil tests revealed that the pH was 5.7 to 6.5, and soil phosphorus and potassium were very high.

The pasures were sprigged in 1975, and grazing trials began in 1977. Each of the pastures was about three acres and was subdivided with electric fences into three paddocks to facilitate rotational grazing during the grazing trials. The rotational grazing objective was one-week grazing of the paddocks followed by a two-week deferment. Thus, throughout most of the bermudagrass growing season, the forage was two and never over three weeks of age.

In early June of each year, each paddock was mowed to remove cool season annuals when steers were rotated. The pastures were fertilized with 150 lb of actual nitrogen per acre each year of the grazing trials. Nitrogen was applied as ammonium nitrate in three equal applications in early April, late June and early August.

Steers of two sources were used in the 1977 grazing trial. Forty-five were raised on the research station. They had grazed small grain pasture for two months prior to the trial and were in fleshy condition at the beginning of the trial. Fifteen steers were purchased at a livestock auction on May 2; they were in thin condition and were placed directly on bermudagrass. The steers, Hereford and Hereford x Angus, were assigned to treatment groups on the basis of source, breed and weight.

All steers (Hereford and Hereford x Angus) for the 1978 trial were purchased at a livestock auction in late March. The steers were grazed on small grain pasture with limited forage until the trial began and were in thin condition at the beginning of the trial.

Daily gains were calculated from weight gains of steers that remained in the pastures throughout each grazing trial (tester steers). Stocking rates on the pastures were adjusted according to the amount of available forage throughout the grazing trials by use of put-and-take steers. For calculation of total steer gains, put-and-take steers were assigned daily gains of tester steers during each period. Steer weights were measured after about a 16-hour overnight shrink without feed or water.

All steers were implanted with 15 mg of diethylstilbestrol at the beginning of each trial. Injectable Tramisol (levamisole phosphate) was given for internal parasite control on July 1, 1977 and twice in 1978 (March and July 1). Excellent fly control was achieved during each trial by spraying the steers on each weigh date and keeping dust bags in the pastures. Steers in all pastures had access to shade from trees or constructed shades. A commercial mineral supplement that contained 12 percent calcium and 12 percent phosphorus was fed free-choice during the trials.

The data were analyzed by analysis of variance. Where F values were significant ($P<.05$), differences among treatment means were tested for significance ($P<.05$) by Duncan's multiple range test.

Table 1. Seasonal precipitation (inches) for Agronomy Research Station, Perkins.

Month	1977	1978	Long Term Average
January	0.22	0.92	1.53
February	1.16	2.63	1.46
March	2.50	1.46	2.20
April	2.23	1.85	3.16
May	8.46	7.28	5.09
June	1.90	4.59	4.58
July	3.15	0.90	3.45
August	2.88	0.53	3.19
September	1.77	0.49	3.81
Total	24.27	20.65	28.47

Table 2. Average daily gains (ADG) of steers, total steer grazing days per acre and total gain per acre (1977 Grazing Trial).[abcd]

Grazing interval	Number of days	ADG, lb[e]				Total steer days/acre				Total gain/acre, lb			
		Midland	Hardie	Oklan	SS-16	Midland	Hardie	Oklan	SS-16	Midland	Hardie	Oklan	SS-16
5-5 to 6-2	28	1.22	1.79	2.14	2.04	41[c]	99[a]	26[d]	47[b]	49[b]	178[a]	55[b]	95[b]
6-2 to 6-30	28	1.52	1.67	1.28	1.29	52	52	52	52	80	87	67	68
6-30 to 8-2	33	1.36	1.33	1.74	1.64	51	51	56	41	69	68	99	66
8-2 to 8-31	29	1.41	1.40	1.26	1.66	62	46	63	40	87	64	76	65
8-31 to 10-5	35	1.71	2.39	2.10	2.29	76[a]	65[b]	49[c]	65[b]	131	155	101	143
Total season	153	1.45	1.73	1.72	1.80	281[ab]	313[a]	246[b]	244[b]	416[b]	552[a]	398[b]	437[b]

[abcd]Means under column headings ADG, total steer days/acre and total gain/acre having no or common lettered superscripts are not significantly different (P>.05).
[e]Six, 8, 6 and 5 tester steers on the Midland, Hardie, Oklan and SS-16 bermudagrass varieties, respectively. Mean ± SEM initial weight of all tester steers was 518 ± 8.4 lb.

Table 3. Average daily gains (ADG) of steers, total steer grazing days per acre and total gain per acre (1978 Grazing Trial).[abc]

Grazing interval	Number of days	ADG, lb[d]				Total steer days/acre				Total gain/acre, lb			
		Midland	Hardie	Oklan	SS-16	Midland	Hardie	Oklan	SS-16	Midland	Hardie	Oklan	SS-16
5-9 to 5-31	22	2.65	3.22	2.36	2.73	20[b]	49[a]	17[b]	20[b]	54[b]	156[a]	40[b]	55[b]
5-31 to 6-30	30	2.00	1.86	2.31	2.00	86[b]	95[a]	48[c]	86[b]	173	177	112	173
6-30 to 8-1	32	1.33	1.72	2.03	1.15	80[a]	59[b]	54[c]	80[a]	105	102	109	92
8-1 to 8-31	30	1.56	.94	1.83	1.33	56[a]	56[a]	46[b]	56[a]	87	52	85	75
Total season	114	1.82	1.84	2.09	1.72	242[b]	259[a]	165[c]	242[b]	419	487	347	395

[abc]Means under column headings ADG, total steer days/acre and total gain/acre having no or common lettered superscripts are not significantly different (P>.05).
[d]Six tester steers on each of the bermudagrass varieties. Mean ± SEM initial weight of all tester steers was 520 ± 6.3 lb.

Results and Discussion

Rainfall recorded on the station during the first nine months of 1977 and 1978, compared with the long term average, is shown in Table 1. Average daily gains of the steers, total steer grazing days per acre, and total gain per acre (by period and the total grazing season) for the 1977 and 1978 grazing trials are shown in Tables 2 and 3.

The 1977 trial was conducted from May 5 to October 5 for a total of 153 days. Average daily gains of steers grazed on the four bermudagrass varieties ranged from 1.22 to 2.39 lb during the five periods of the trial and from 1.45 to 1.80 lb for the total season. Differences among average daily gains of steers grazed on the four bermudagrass varieties, within periods or for the total season, were not significant ($P>.05$).

Stocking rates (total steer days/acre) during the early summer period (May 5 to June 2) were the highest on the Hardie pastures (99 steer days) and the lowest on the Oklan pastures (26 steer days). For the remainder of the trial, stocking rates were similar among the four bermudagrass varieties except for the last period in which Midland bermudagrass supported the highest stocking rate.

Total gain per acre was much higher, during the first period of the trial, on the Hardie pastures (e.g., about 3.6-fold greater than Midland pastures). Total steer gain for the total grazing season was 552 lb per acre on the Hardie bermudagrass pastures and was greater ($P<.05$) than total gains on the other pastures which were about 417 lb (mean of total gains on the other pastures).

Because of a very dry late summer, the 1978 grazing trial was terminated on August 31 after 114 days (Table 3). Average daily gains of steers during the first period (May 9 to May 31) were extremely good and ranged from 2.36 to 3.22 lb. Average daily gains for the total season range from 1.72 to 2.09 lb. As in the 1977 trial, differences among average daily gains of steers grazed on the four bermudagrass varieties, within periods or for the total season, were not significant ($P>.05$).

Although stocking rates were lower during the 1978 trial than the 1977 trial, the relative differences in the first period of the trial (e.g., much higher for Hardie than the other varieties) were consistent with those of the first grazing trial. Stocking rates were the lowest on the Oklan pastures throughout the trial due to apparent winter killing of the bermudagrass.

Total steer gains (lb/acre) for the total grazing season were the greatest on the Hardie pastures (487 lb), similar on the Midland and SS-16 pastures (419 and 395 lb) and the lowest on the Oklan pastures (347 lb). Differences among total steer gains among the four bermudagrass varieties were not significant ($P>.05$).

The results of these trials show that bermudagrass varieties differ markedly in amount of forage produced during various periods of the bermudagrass growing season and, therefore, in total beef production. Hardie bermudagrass was particularly impressive in these trials in regard to early forage production. Differences in carrying capacity (e.g., 41 to 76 and 20 to 86 total steer days/acre of Midland bermudagrass during the 1977 and 1978 trials) indicate that stocking rate adjustment is a critical management problem in bermudagrass stocker programs. Average daily gains of steers were very good in these trials (1.45 to 1.80 lb and 1.72 to 2.09 lb for the total grazing seasons of 1977 and 1978), and emphasize the importance of pasture management in maintaining an immature, growing forage.

Literature Cited

Oliver, W.M. 1976. Research Report prepared for meeting of the Louisiana Forage Council.

Seasonal Changes in the Nutritive Value of Five "Old World Bluestems"

F. P. Horn and C. M. Taliaferro

Story in Brief

Five varieties of Old World Bluestems were established at the Southwestern Livestock and Forage Research Station in 1973. Samples of the forage were collected weekly for two years during each growing season. The samples were dried then ground for laboratory analysis of "test-tube" digestibility (IVDMD), protein (CP), fiber (NDF and ADF) and lignin (ADL). The results were used to estimate the magnitude and nature of seasonal effects on the feeding value of the forage.

Introduction

Forages generally decline in feeding value as the growing season advances. Different forages vary, however, in their peak quality as well as their rate of quality-decline. Thus, as well-adapted, productive forages are developed or selected, frequent serial sampling for several growing seasons is necessary for an evaluation of the worth of the new material as a livestock feed.

In recent years, the group of grasses dubbed "The Old World Bluestems (OWBS's)" has been the subject of extensive agronomic study. These grasses, blends of ecotypes from India, Pakistan and Turkey, are known to be high yielding, pest and disease resistant, responsive to fertilization and high in *in vitro* dry matter digestibility (IVDMD) when grown in the Southern Great Plains. They are especially well adapted to the "Hard Redlands," an area which is notably devoid of highly productive perennial grass species. Both as a soil conservator and as livestock feed, these grasses are potentially important.

The seasonal changes in the nutritive value of five varieties of OWBS's, estimated on the basis of determinations of chemical composition and IVDMD, are the subject of this report.

Materials and Methods

Five Old World Bluestems were established in large plots (two to six acres) in the spring of 1973. The varieties chosen were "Caucasian," "Plains," "T-Blend," "B-Blend" and "L-Blend." Beginning in the spring of 1974, samples of forage were clipped from each plot at roughly one-week intervals throughout each of the next two growing seasons. These plots were established on a Dale silt loam with 0-5 percent slope.

As samples were collected, they were carefully weighed, dried in a forced-air oven at 65 C, then ground for laboratory analysis.

Results and Discussion

Patterns of change for each variety and each component are shown in Figure 1. Each line represents the "average" trend of the two years studied.

USDA, Science and Education Administration, Southern Region, in cooperation with Oklahoma Agricultural Experiment Station.

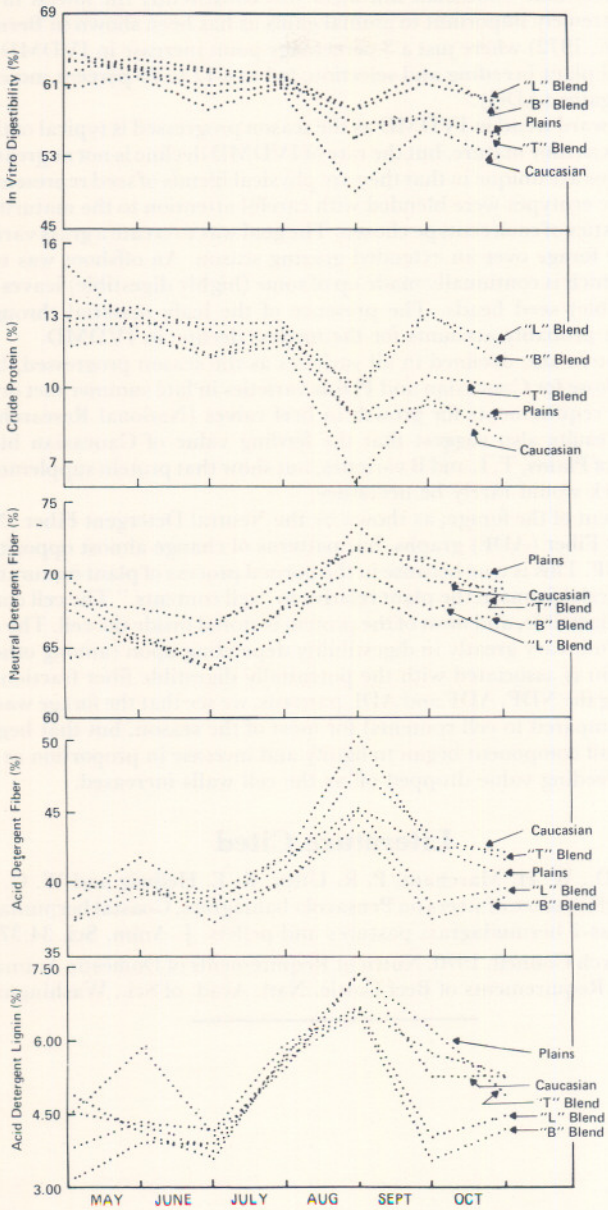


Figure 1. Seasonal changes in the *In vitro* digestibility (IVDMD) and chemical components of five Old World Bluestems (values are an average of two years).

Digestibility (IVDMD) and crude protein (CP) are most important in determining the feeding value of the forage; the remaining fractions can, however, help us understand why the changes in digestibility occur and thereby help us select the variety most suited to our needs.

IVDMD values for these forages were not very different until August, but it is important to note that Caucasian Bluestem was consistently the lowest in IVDMD. This can be extremely important to animal gains as has been shown in Bermudagrass (Chapman *et al.*, 1972) where just a 3 percentage point increase in IVDMD, achieved through careful plant breeding and selection, led to a 12 to 15 percent increase in calf average daily gains (ADG).

The downward trend in IVDMD as the season progressed is typical of that shown by most grasses as they mature, but the rate of IVDMD decline is not as great. The Old World Bluestems are unique in that they are physical blends of seed representing many ecotypes. These ecotypes were blended with careful attention to the maturity (flowering) characteristics of each ecotype chosen. The goal was to create a grass variety which would produce forage over an extended grazing season. An offshoot was to create a grass variety which is continually made up of some (highly digestible) leaves and some (poorly digestible) seed heads. The presence of the leafy material throughout the growing season probably accounts for the modest decline in IVDMD.

Crude protein also declined in all varieties as the season progressed, but all CP values except those for Caucasian and Plains varieties in late summer met or exceeded the nutritional requirements for growth in beef calves (National Research Council, 1970). These results also suggest that the feeding value of Caucasian bluestem is inferior to that of Plains, T, L and B varieties, but show that protein supplementation of grazing livestock would rarely be necessary.

Fiber content of the forage, as shown by the Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) graphs, has patterns of change almost opposite those of IVDMD and CP. This is true because in the normal process of plant maturation, more "cell wall" material forms in the plant relative to "cell contents." The cell contents are almost totally digestible, and most of the protein is stored inside the cell. The cell walls, on the other hand, vary greatly in digestibility depending upon (among other things) how much lignin is associated with the potentially digestible fiber fractions.

Comparing the NDF, ADF and ADL patterns, we see that the forage was lush and low in fiber (compared to cell contents) for most of the season, but that beginning in July, the cell wall component began to lignify and increase in proportion as the plant matured. The feeding value dropped off as the cell walls increased.

Literature Cited

Chapman, H. D., W. H. Marchant, P. R. Utley, R. E. Hellwig and W. G. Monson. 1972. Performance of steers on Pensacola bahiagrass, Coastal bermudagrass and Coastcross-1 bermudagrass pastures and pellets. J. Anim. Sci. 34:373-378.

National Research Council. 1970. Nutrient Requirements of Domestic Animals. No. 4. Nutrient Requirements of Beef Cattle. Natl. Acad. of Sci., Washington, D. C.

Grazing Preference of Four Bermudagrass Varieties by Bulls

D. C. Meyerhoeffer and S. W. Coleman

Story in Brief

Four bermudagrass varieties, two released (Oklan and Midland) and two experimental (OSU-S-15 and OSU-S-23), were evaluated for grazing preference by beef bulls. Fifty lb of nitrogen were added per acre in early spring and midsummer with irrigation being applied as needed. One Angus bull grazed each one-acre pasture. Oklan was grazed more frequently ($P<.05$) than the other varieties; experimental variety OSU-S-15 was least preferred ($P<.05$). Relative yields as estimated by densitometer were highest for Oklan and followed by OSU-S-15, OSU-S-23 and Midland.

Introduction

Many factors are involved in assessing the quality of forages for use by livestock. Among these are digestibility, intake by the animal, weight gain per animal or animal production per unit area. One attribute which may influence the animal's intake of a forage is its preference of palatability. The objectives of this study were to determine grazing preference of four bermudagrass varieties by estimating the time spent grazing each one.

Materials and Methods

Four one-acre pastures of Bermudagrass varieties were used, and the plot design is shown in Figure 1. Each pasture was equally divided and planted to Midland, Oklan, OSU-S-15 and OSU-S-23 varieties which were randomly allotted within each pasture.

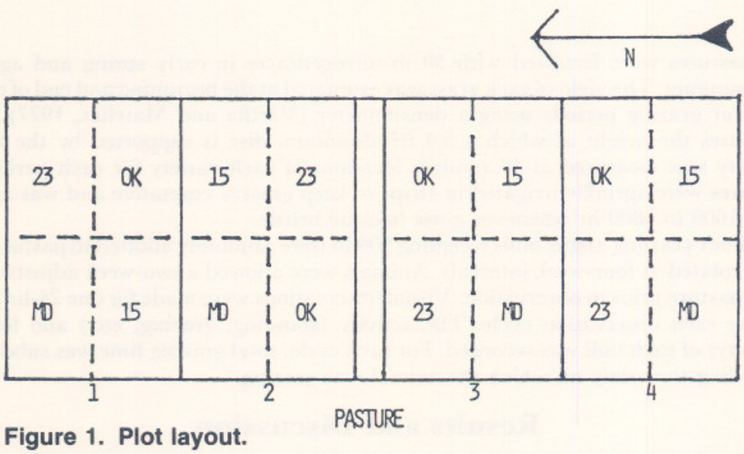


Figure 1. Plot layout.

USDA, Science and Education Administration, Southern Region in cooperation with Oklahoma Agricultural Experiment Station.

Table 1. Influence of variety on hours spent grazing.

Variety	Hours Grazing
Midland	1.19[a]
Oklan	2.31[b]
OSU-S-15	.58[c]
OSU-S-23	1.30[a]

a,b,cP<.01

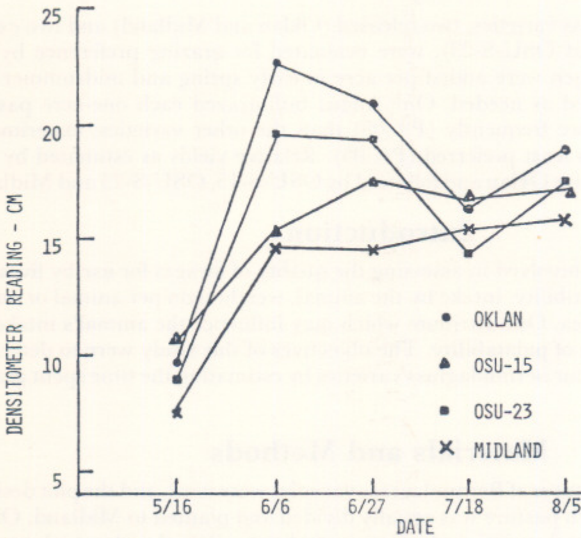


Figure 2. Measurements of density.

All pastures were fertilized with 50 lb nitrogen/acre in early spring and again in mid-summer. The yield of each grass was estimated at the beginning and end of each of the four grazing periods using a densitometer (Vartha and Matches, 1977) which measures the height at which a 5.4 ft^2 aluminum disc is supported by the forage. Density was measured at 10 random locations of each variety for each period. All pastures were sprinkle irrigated in strips to keep grasses vegetative and was applied from 1600 to 0800 hr whenever grass became brittle.

Four yearling angus bulls weighing 900 lb were randomly allotted to pastures and were rotated at four-week intervals. Animals were allowed a two-week adjustment in each pasture prior to observation. Visual observations were made for one 24-hr period during each observation cycle. The activity (standing, grazing, etc.) and location (variety) of each bull was recorded. For each cycle, total grazing time was subdivided according to variety on which the animal was grazing.

Results and Discussion

Generally, animals grazed in the early morning from about 0600 to 0900 hr and early evening from 1600 to 2000 hr. Very short grazing periods were observed between 1100 to 1300 and 2300 to 2400 hr. Total grazing time was four to five hr per day. The

Oklan variety was preferred by the bulls as indicated by hr spent grazing (Table 1). Experimental variety OSU-S-15 was the least preferred; whereas, Midland and OSU-S-23 were intermediate.

Other trials conducted at the Southwestern Livestock and Forage Research Station (Horn, et al., 1976) have shown that Oklan bermudagrass is higher in digestibility than other varieties included in this test, which may account for the preference shown in this experiment. However, OSU-15 was intermediate in digestibility and lowest in preference while Midland was lowest in digestibility and intermediate in preference.

Densitometer readings for the various species on the various sampling dates are shown in Figure 2. Such measurements are correlated with yield in that the higher the densitometer reading, the more forage available (Vartha and Matches, 1977). These data indicate that Oklan has the highest forage availability which may partially account for higher preference for this variety. However, ample forage was available in all plots and was unlikely to have been so deficient as to affect preference. Because of hot weather, the forage was quite dormant even though irrigation was applied.

There was an infestation of Johnsongrass during the early months of May and June due to the characteristic late emergence of the Oklan variety. When present, Johnsongrass was preferred over any bermudagrass variety. It should be kept in mind that preference of a grass is only one attribute of forage quality and does not necessarily indicate expected performance.

Literature Cited

Horn, F. P., C. M. Taliaferro, and R. D. Morrison. 1976. Yield and quality of Midland and two new F1 hybrid bermudagrasses. Agron. J. 68:129.

Vartha, E. W. and A. G. Matches. 1977. Use of a weighted disk measure as an aid in sampling the herbage yield on tall fescue pastures grazed by cattle. Agron. J. 69:888.

Frequency of Feeding Small Grains Range Grass Hay

S. W. Coleman and R. D. Wyatt

Story in Brief

Small grains forage (SGF) was fed at three frequencies to determine its usefulness as a nitrogen (N) supplementation for dormant native grass hay. Twelve steers (265 kg BW) were randomly assigned to one of four treatments (feeding frequency): (1) control - tall native range hay; (2) range hay plus 11.3 kg of green chopped SGF daily; (3) range hay plus 22.7 kg of green chopped SGF on alternate days; and (4) range hay plus 45.4 kg of green chopped SGF every fourth day. After a three-week preliminary period, four consecutive 1-week periods for total collection of feces and urine followed.

The SGF consisted of wheat (immature to soft dough) during the preliminary and first two collection periods and oats (immature to early boot) during the last two collection periods. The addition of SGF to the basal diets significantly increased ($P<.05$) digestibility of dry matter from 36.7 to 43.7 percent and of N from -17.1 to 46.5 percent. However, the interaction between feeding frequency and period for digestibility of N was significant ($P<.05$). The animals were marginal to negative in N balance, even when SGF was fed. Nitrogen balance was also influenced by a significant feeding frequency x period interaction. For both parameters, most of the interaction was due to the control treatment.

In general, digestibility and N-balance increased until period 3 and then decreased the fourth period. Digestibility was less in animals fed every fourth day than in animals fed every day. The data indicate that animals can be fed SGF infrequently and, with adaptation, maintain higher N balance than when they are fed low-protein basal rations such as range hay.

Introduction

Protein deficiency has been shown to be the first limiting nutrient of dry cows grazing dormant native range grass in Oklahoma and also constitutes the greatest part of the cost associated with cow-calf operations. Small grain forages (SGF) are relatively high in crude protein (CP) and are available for grazing when supplemental protein requirements are greatest. In addition, SGF, especially winter wheat, are available for pasture in the Southern and Central Great Plains where native grass range is used for cow-calf production. Though dry, or even lactating, cows do not need forage as high in quality as wheat, limited grazing for supplemental benefits may be profitable. The frequency of grazing has not been determined. This research was begun to determine the influence of frequency of feeding SGF on dietary nitrogen (N) utilization when the basal diet was dormant native range grass hay.

Experimental Procedure

Design

Twelve English crossbred steers were randomly assigned to one of four treatments (feeding frequency): (1) Range hay (control); (2) range hay plus 11.3 kg of SGF each day; (3) range hay plus 22.7 kg of SGF on alternate days; and (4) range hay plus 45.4 kg

USDA, Science and Education Administration, Southern Region, in cooperation with Oklahoma Agricultural Experiment Station.

of SGF every fourth day. They were placed in metabolism stalls designed for separation of feces and urine and allowed three weeks for adaptation. Four consecutive 7-day collection periods followed. Within each collection period, timing was arranged so that animals on treatment 4 were fed SGF twice. Feces and urine were collected and processed as described by Coleman and Barth (1974).

Forages

Basal diet consisted of mature tall-grass, native range hay grown on the Southwestern Livestock and Forage Research Station, El Reno, OK. The hay was cut and baled in March. Primary composition was *Andropogon scoparius*, *Andropogon gerardi* and *Andropogon hallii*.

The hay was chopped through a 2.5 cm screen before feeding. Supplementary SGF consisted of two types because of a rapid increase in maturity of wheat forage. During the preliminary period and the first two collection periods, wheat forage was used. During the second collection period, the wheat was so mature that greater than 50 percent was in boot to early dough stage. During the last two collection periods, vegetative material from spring-planted oats was fed. All SGF was chopped with a flail harvester daily at 8 am and fed immediately. Animals fed SGF at 4-day intervals were fed in two equal increments. The amount of green chop offered was determined by observing the amount consumed in 1 hr by animals assigned to daily feeding of SGF.

Daily samples of the wheat forage were collected and dried at 100 C for dry matter (DM) determination. Another sample was collected and dried for three days at 65 C, allowed to air equilibrate, ground to pass a 1-mm screen and stored for chemical analysis. When refusals of wheat exceeded 2.5 kg, samples were taken for DM; otherwise, DM of refusal was assumed to be equal to that of the forage.

Chemical Analysis

All air-dry forage and fecal samples were analyzed for 100 C dry matter, ash and N. Urine was analyzed for N (AOAC, 1970). Acid-detergent fiber, neutral-detergent fiber, permanganate lignin and cellulose were determined according to procedures described by Goering and Van Soest (1970). Total non-structural carbohydrates (TNC) were determined on daily SGF samples (Smith, 1969). Coefficients of digestion were calculated for each nutrient. Also N retention was determined and expressed as a percentage of intake and absorbed N.

Statistical

The data were analyzed with the appropriate analysis of variance for split-plot design. Days between feeding SGF (treatments) were main effects and collection periods were subordinate effects.

Results and Discussion

Chemical composition of dietary components are presented in Table 1. The hay was severely weathered as indicated by low CP and TNC. The wheat and oat green chop varied little among trials, except that CP of the oats was higher than that of wheat. Conversely, TNC of oats was lower than that of wheat.

Overall ration intake and nutrient digestibility are presented in Table 2. Dry matter intake (DMI), whether calculated as actual intake, intake/100 kg of body weight or intake/metabolic body size, was lowest ($P<.05$) for the control. The DMI of steers fed SGF every day was not different from that of steers fed every other day, but DMI was depressed ($P<.05$) for steers fed SGF every fourth day. Digestibility of DM, organic matter (OM) and CP were significantly ($P<.05$) affected by frequency of feeding SGF. Digestibility was lowest for the control treatment. Digestibility of DM, OM and CP declined slightly as the interval between feeding SGF increased. This

Table 1. Nutrient composition of forage.

Nutrient	Range hay	Wheat Period 1	Wheat Period 2	Oats Period 3	Oats Period 4
	%				
Dry matter	87.3	22.5	24.6	16.2	16.4
Organic matter	93.2	91.8	91.0	86.9	88.0
Crude protein	3.3	11.7	14.0	20.2	17.2
Neutral-detergent fiber	75.6	45.8	48.6	46.4	47.3
Acid-detergent fiber	53.9	26.1	26.1	26.5	27.0
Lignin	12.3	3.9	3.9	3.5	3.5
Cellulose	36.9	19.7	20.0	17.6	19.3
Hemicellulose	21.7	19.7	22.5	19.9	20.3
TNC[a]					
Non-hydrolyzed	1.8	10.0	13.3	6.4	7.8
Hydrolyzed[b]	.4	16.9	15.0	7.0	9.9

[a]Total non-structural carbohydrates.
[b]Contains fructosans.

Table 2. Ration intake and nutrient digestibility.

Item	Control	Feeding frequency, days		
		1	2	4
Average weight, kg				
Initial	284	287	290	283
Final	235	276	296	259
Dry matter intake				
kg/day	2.14[a]	5.56[c]	5.26[c]	4.22[b]
kg/100 kg BW[d]/day	.82[a]	1.98[c]	1.80[c]	1.57[b]
g/w$^{.75}_{kg}$/day	33.0[a]	81.1[c]	74.4[c]	63.5[b]
Digestibility, %				
Dry matter	36.7[a]	45.8[c]	44.6[bc]	40.6[ab]
Organic matter	40.5[a]	49.7[b]	48.0[b]	44.5[ab]
Crude protein	−17.1[a]	49.0[c]	48.6[c]	41.7[b]
NDF[d]	46.1	45.6	43.7	41.3
ADF[d]	40.2	36.8	35.6	33.6
Cellulose	58.4	56.1	52.5	52.0
Hemicellulose	61.0	61.9	59.8	56.1
Lignin	9.0	8.6	9.2	4.7

[a,b,c]Values in same row not followed by the same superscript are significantly different (P<.05).
[d]BW = body weight; NDF = neutral-detergent fiber; ADF = acid-detergent fiber

Table 3. Nitrogen intake and utilization.

Item	Control	Feeding frequency, days		
		1	2	4
Nitrogen, g/day				
Intake	11.2[e]	71.7[g]	68.7[g]	51.7[f]
Fecal	13.0[e]	36.1[g]	34.5[g]	28.3[f]
Urinary	10.1[e]	38.1[g]	35.3[g]	24.2[f]
MFN[a]	11.2	28.7	27.4	22.2
EUN[b]	7.1	7.4	7.6	7.3
Absorbed	−1.8[e]	35.6[g]	34.2[g]	23.3[f]
Retained	−11.9	−2.6	−1.1	−.8
N retained/N intake, %	- -	−4.5	−4.3	−13.1
N retained/N absorbed, %	- -	−11.5	−13.3	−70.6
Biological value[c]	70.3	51.6	53.5	52.4
Net protein utilization[d]	58.5	46.3	47.8	47.4

[a]Metabolic fecal N = Fecal DM x (3.62 = .13 dry matter digestibility), Swanson, 1977.
[b]Endogenous urinary N = .43 $W^{.505}_{kg}$, Swanson, 1977.
[c]BV = (N intake - (Fecal N-MFN) - (urinary N - EUN))/(N intake - (fecal N - MFN)).
[d]NPU = (N intake - (fecal N - MFN) - (urinary N - EUN))/N intake.
[e,f,g]Values in the same row not followed by the same superscript are significantly different (P<.05).

decline may be a reflection of the fact that slightly lower amounts of the dietary DM were furnished by SGF, especially when fed at 4-day intervals. Digestibility of various fiber fractions was not influenced by SGF feeding frequency.

Digestibility of all fractions was affected (P<.05) by period. Digestibility of CP, acid-detergent fiber and lignin increased through the third period and then decreased in the fourth. Digestibility of other nutrients were essentially constant through the first three periods and decreased in the fourth. Digestibility of CP, ADF and lignin were influenced by an interaction of feeding frequency and period.

Utilization of N is presented in Table 3. With respect to frequency of feeding SGF, N intake, fecal N, urinary N and absorbed N followed similar patterns. The fact that the animals were in negative N balance regardless of treatment indicates that N intake was inadequate for young growing steers. Deficit N balance amounted to 4-13 percent of intake N or 11-71 percent of absorbed N. The control ration, as expected, resulted in the lowest N status. Nitrogen balance of steers fed SGF daily was not different from that of steers fed SGF every other day. When SGF was fed at 4-day intervals, however, the amount of N consumed, excreted and absorbed decreased. Again, period effects were significant for all parameters of N balance. Nitrogen status increased through period three and then decreased in period four. An interaction ($P<.05$) was observed for fecal, urinary, absorbed and retained N, due primarily to a lack of period effect for the control ration.

When the data were adjusted for endogenous and metabolic N, no significant differences occurred due to feeding frequency and average utilization of dietary N approached 50 percent.

These data indicate that infrequent feeding of SGF may be used to supplement range forage. This technique might become important for limited grazing of brood cows to furnish their supplemental winter protein requirements. Total dietary N intake decreased slightly when SGF was fed at 4-day intervals, but this decrease was accompanied by reduced excretion and resulted in no differences in N retention or utilization.

Literature Cited

A.O.A.C. 1975. Official Methods of Analysis (12th Ed.). Association of Official Agricultural Chemists. Washington, D.C.

Coleman, S. W. and K. M. Barth. 1974. Nutrient digestibility and N-metabolism by cattle fed rations based on urea and corn-silage. J. Anim. Sci. 39:408.

Goering, H. K. and P. J. Van Soest. 1970. Forage Fiber Analysis. USDA Agriculture Handbook No. 379.

Smith, Dale. 1969. Removing and Analyzing total nonstructural carbohydrates from plant tissue. Wisconsin Agric. Exp. Sta. Research Report No. 41 (11 p).

Swanson, E. W. 1977. Factors for computing requirements of protein for maintenance of cattle. J. Dairy Sci. 60:1583.

Digestibility of Five "Old World Bluestem" Hays

F. P. Horn and W. Jackson

Story in Brief

Hays from five Old World Bluestems were harvested in 1974 and 1975, then fed to calves in conventional digestion trials. Plains bluestem, Caucasian bluestem, "T"-Blend, "L"-Blend and "B"-Blend were the varieties studied. Results showed few differences between varieties in dry matter digestibility (DMD), intake or N-retention, although Plains was most often highest in quality and "B"-Blend was most often lowest in quality. High relative yields of Caucasian bluestem hay probably offset the slight disadvantage of lower quality.

Introduction

Laboratory data are good indicators of the *relative* feeding values of forages, but in order to truly know the productive potential of a forage, it must be evaluated in animal feeding trials. Caution dictates that through digestion and intake trials we evaluate the forages most-likely to be of value. Digestibility reflects the availability of nutrients to the animal as a result of the digestive process. Intake reflects the many factors which cause an animal to want to eat a particular forage. These two criteria thus indicate the feeding value of a forage.

Materials and Methods

Five varieties of Old World Bluestems were established in 1973 in plots ranging in size from 2.02 to 5.96 acres (because of the scarcity of some seed). The site was on a Dale silt loam with 0 to 5 percent slope at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma. The area was clean-tilled, and a firm seedbed was prepared prior to planting. A "chaffey seed" drill was used to row plant the grass at ½ inch depth. Weeds were controlled by herbicide applications the first year and nitrogen fertilizer was applied in three applications of 50 lb each, every year. Top growth was removed in the year of establishment, but hay for the studies herein reported were collected in 1974 and 1975.

Hay was harvested three times in each of the test years (1974-1975), resulting in 30 hays for evaluation. All hay was cut, suncured and removed in "conventional" bales. As hay was removed from each plot, the yield per acre was determined. It was then stored under cover until the initiation of feeding trials.

Hays were chopped to a length of about one inch just before feeding. To determine digestibility and nitrogen balance, beef steers weighing 450 to 650 lb were randomly assigned to conventional digestion stalls and fed the test hays in 14-day trials (a seven-day "preliminary" period followed by a seven-day "collection" period). Hay was fed twice each day and at each feeding was adjusted to allow for approximately 10 percent refusal. In total, five steers were used to evaluate each hay.

Results and Discussion

The hay yields for the 1974 and 1975 seasons are shown in Table 1. Several factors influenced these results. The site where these hays were grown in highly productive and might be more suited to grain crop production under current economic conditions. In

Table 1. Hay yields (tons/acre) from Old World Bluestem plots in 1974 and 1975[1].

	1974				1975			
Blend/Cut	**1**	**2**	**3**	**Total**	**1**	**2**	**3**	**Total**
Plains	1.94	1.78	2.16	5.88	2.04	1.90	2.13	6.07
Caucasian	2.12	1.74	2.14	6.00	2.10	1.95	2.19	6.24
"T"-blend	1.60	1.79	1.96	5.35	1.70	1.59	2.07	5.36
"L"-blend	2.04	2.07	2.23	6.34	2.26	2.11	2.49	6.86
"B"-blend	2.12	2.06	2.52	6.70	2.32	2.16	2.50	6.98

[1]First and second cut 1974 values were determined by randomly selecting bales, weighing, then counting bales. Thereafter, all hay removed from the plots was weighed on the truck.

Table 2. Chemical composition of hays harvested from Old World Bluestem plots in 1974 and 1975[1].

Variety	Year	Cut	IVDMD	Chemical composition			
				CP	NDF	ADF	ADL
Plains	1974	1	56.0	11.5	73.6	46.0	4.56
		2	57.5	10.1	71.6	39.0	3.71
		3	59.2	11.0	69.9	40.6	5.11
	1975	1	54.6	11.9	76.9	48.3	4.69
		2	55.9	8.0	75.2	47.1	5.60
		3	56.2	9.8	73.6	43.5	3.96
Caucasian	1974	1	54.1	10.6	72.2	45.6	4.53
		2	57.8	9.8	73.4	41.2	4.33
		3	55.6	9.5	71.6	43.1	4.63
	1975	1	52.1	10.0	75.4	48.9	5.18
		2	54.3	6.8	72.7	48.9	4.39
		3	53.3	8.8	69.2	46.4	5.98
"T"-blend	1974	1	53.2	10.8	74.9	48.7	6.48
		2	60.0	10.9	69.1	37.0	3.73
		3	59.7	11.1	71.3	42.5	4.96
	1975	1	53.1	10.4	74.4	48.8	5.21
		2	57.2	10.0	73.4	45.8	5.06
		3	56.3	10.0	70.3	42.7	3.52
"L"-blend	1974	1	53.6	10.3	75.6	48.5	6.06
		2	56.5	8.5	68.2	40.4	4.62
		3	58.1	10.1	72.5	43.6	4.69
	1975	1	54.8	10.2	77.4	50.8	5.60
		2	57.9	10.1	74.0	44.0	4.35
		3	57.6	9.3	71.8	42.3	3.52
"B"-blend	1974	1	54.2	10.9	75.0	47.8	5.80
		2	58.6	8.9	69.4	39.8	4.85
		3	55.3	10.1	73.8	43.5	4.92
	1975	1	55.2	11.7	74.4	49.1	5.15
		2	57.0	11.7	72.4	43.2	4.05
		3	56.1	9.8	72.8	43.3	3.51

[1]All values are presented as a percent of the dry matter.

addition, while this was "dry land" hay production, both years shown had "good" rainfall distribution during the growing season. Nevertheless, these values indicate the productive potential of Old World Bluestems and give valid comparisons of the five varieties studied.

Quality data (Horn and Taliaferro, 1979) have shown that over the growing season, Caucasian bluestem is not as high in feeding value as is the Plains variety. There are, however, circumstances when the higher yield inherent in Caucasian bluestem may more than offset the lower quality. These results illustrate the importance of carefully analyzing the nutritional requirements of the class of livestock owned before establishing new pastures.

The *in vitro* dry matter disappearance (IVDMD) and chemical composition of the hays are shown in Table 2. Based on *laboratory data*, Plains and "T"-Blend were highest in *predicted* quality, Caucasian and "L"-Blend were intermediate and "B"-blend was

Table 3. ***In vivo*** **dry matter digestibility of Old World Bluestem hays harvested in 1974 and 1975.**

Year	Cut	Variety					Average
		Plains	Caucasian	"T"-blend	"L"-blend	"B"-blend	
1974	1	59.9	60.0	57.0	56.7	56.2	57.7
	2	58.3	57.2	58.4	56.9	57.3	57.6
	3	70.2	70.4	71.5	71.8	68.8	70.5
	Average	62.8	62.5	62.3	61.8	60.8	
1975	1	60.2	54.0	55.4	53.4	51.8	55.0
	2	55.2	57.6	59.8	57.9	59.7	58.0
	3	57.6	57.7	54.1	54.5	57.9	56.4
	Average	57.7	56.4	56.4	55.3	56.5	

Table 4. Voluntary intake by calves of Old World Bluestem hays harvested in 1974 and 1975[1].

Year	Cut	Variety					Average
		Plains	Caucasian	"T"-blend	"L"-blend	"B"-blend	
1974	1	5.09	5.57	4.23	4.73	4.64	4.84
	2	5.72	5.97	5.93	5.48	5.98	5.80
	3	7.18	7.58	7.10	7.04	6.85	7.16
	Average	6.00	6.37	5.75	5.75	5.83	
1975	1	5.78	6.96	6.48	5.73	6.26	6.26
	2	4.47	4.24	5.66	4.76	4.73	4.74
	3	5.42	4.75	5.73	4.91	5.59	5.28
	Average	5.22	5.32	5.96	5.13	5.53	

[1]Voluntary intake = DM intake/animal/day during digestibility trials.

Table 5. Nitrogen retention by calves fed Old World Bluestem hays harvested in 1974 and 1975.

Year	Cut	Variety					Average
		Plains	Caucasian	"T"-blend	"L"-blend	"B"-blend	
1974	1	32.74	37.56	26.52	30.19	24.75	30.25
	2	25.89	20.20	33.48	30.07	25.37	27.37
	3	50.22	46.18	48.32	48.71	44.97	47.68
	Average	36.28	34.65	36.11	36.32	31.70	
1975	1	32.82	24.50	34.00	21.21	23.42	27.44
	2	12.27	15.71	27.36	25.22	32.32	22.38
	3	31.00	40.07	27.04	25.49	25.48	29.82
	Average	25.36	26.76	29.47	23.97	27.07	

lowest. It is especially important to note crude protein (CP) values of all Old World Bluestem hays were adequate for growth, except for the second-cut Caucasian hay value in 1975.

The *in vivo* dry matter digestibility (DMD) values for the hays are shown in Table 3. Note that in live animal trials, the hays were not different in digestibility. Differences between cuts, however, were sizeable. Digestibility results are supported by those of voluntary intake (Table 4) and N-retention (Table 5) studies. All hays evaluated were relatively high-quality forages.

These results demonstrate the potential of the Old World Bluestems for hay production. Careful consideration should be given to the "target" animal's nutrient requirements before a variety of Old World Bluestem is selected. Of the varieties available (Plains bluestem and Caucasian bluestem), Plains is slightly higher in quality-of-hay produced, but Caucasian bluestem yields more hay per acre.

Literature Cited

Horn, F. P. and C. M. Taliaferro. 1979. Animal Science Research Report, MP-104. Okla. Agric. Exper. Sta. & USDA.

Productivity Comparisons of Various Three-Year-Old Crossbred Cow Groups

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Story in Brief

Productivity was measured on 303 three-year-old crossbred cows of eight different two-breed crosses (Hereford-Angus, Angus-Hereford, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) when mated to Brahman and Charolais bulls.

The percentage of cows exposed to breeding that weaned a calf ranged from 29.7 percent for Brown Swiss-Angus cows to 88.4 percent for Jersey-Hereford cows. The percentage of cows calving that required assistance in calving ranged from 11.4 percent for Jersey-Angus cows to 48.5 percent for Simmental-Angus Cows.

Calves from Simmental, Brown Swiss and Jersey crosses were from 10.0 to 14.6 percent heavier than calves from reciprocal Hereford-Angus cross cows. Jersey cross and Simmental cross cows produced 31.1 percent and 14.2 percent, respectively, more lb of calf weaned per cow exposed in the breeding herd than Hereford-Angus reciprocal cross cows. Brown Swiss-Angus and Brown Swiss-Hereford cows were 7.8 and 51.8 percent, respectively, less productive.

Using the ratio of calf weaning weight to cow metabolic weight as a measure of cow efficiency, Jersey cross, Brown Swiss cross and Simmental cross cows were 19.9, 10.8 and 5.4 percent more efficient, respectively, than Hereford-Angus reciprocal cross cows.

Introduction

Crossbreeding is increasingly being utilized to increase the efficiency of producing beef. Research studies have indicated that the lb of calf weaned per cow exposed in the breeding herd can be increased to 20 to 25 percent by planned crossbreeding systems. Since over half of the increased productivity from crossbreeding systems results from using crossbred cows, an extensive research program is presently underway at the Oklahoma Agricultural Experiment Station to compare lifetime productivity of various two-breed cross cows mated to bulls of a third breed. The purpose of this study was to compare productivity of various two-breed cross cow groups as three-year-olds.

Experimental Procedures

Angus and Hereford cows were mated to produce crossbred calves in 1973, 1974 and 1975 sired by Angus, Hereford, Simmental, Brown Swiss and Jersey bulls. Four different bulls of each breed were used each year. All heifer calves (a total of 434) produced by these matings were kept in the herd for evaluation. These crossbred heifers

In cooperation with USDA, Science and Education Administration, Southern Region.

were mated to Red Poll and Shorthorn bulls to produce their first calf at two years of age in the spring of 1975, 1976 and 1977 (productivity as two-year-olds has been summarized in the 1978 Animal Science Research Report MP-103: 105-111).

The cows born in 1973 and 1974 were mated to Charolais and Brahman bulls for their second breeding season to produce calves as three-year-olds in the spring of 1976 and 1977. A different set of four Charolais and three Brahman bulls were used each year. The cows born in 1975 were mated to Charolais bulls only and thus were not included in this study.

All cattle were managed on native and bermuda grass pasture at the Lake Carl Blackwell Research Range. Cows were exposed to breeding from May 1 to July 15 each year; thus, calves were born mostly in February and March. Calves were weaned in the fall at an average age of 205 days.

All traits other than reproduction were analyzed by general least squares procedures. The production traits summarized for each crossbred cow group have been adjusted for all significant factors and two-factor interactions, as appropriate, based on preliminary analyses. For example, the 205-day average weaning weights were adjusted for sire breed, year, sex of calf and sire within sirebreed and year.

Results and Discussion

Table 1 presents the reproductive and calving performance of the three-year-old crossbred cows. Of the 303 cows exposed to breeding, 71.9 percent calved and 67.7 percent weaned a calf. As two-year-olds, 77 percent of the heifers exposed weaned a calf. This reduction in reproductive performance as three-year-olds demonstrates the difficulty that lactating two-year-old cows have rebreeding under range conditions. There was considerable variation in the percentage of cows exposed to breeding that weaned a calf ranging from 88.4 percent for Jersey-Hereford cows to 29.7 percent for Brown Swiss-Hereford cows with the other crossbred groups intermediate.

Each calf was assigned a calving difficulty score by the herdsman. Percent calving difficulty is the percentage of births that were categorized as difficult births and required assistance from the herdsman. Based on the scoring system used, births scored 3 or higher were categorized as difficult births. Simmental-Angus cows experienced the most calving difficulty (48.5 percent difficult births and average calving score of 2.5) and the others were not significantly different from each other and ranged from Simmental-Hereford (31.6 percent difficult births and average calving score of 1.9) to Jersey-Angus (11.4 percent difficult births and average calving socre of 1.5).

Of the 218 cows that calved, 27.1 percent required assistance which is more calving difficulty than most commercial producers could tolerate. These data would suggest that the use of bulls from the larger, more muscular breeds (Charolais and Brahman in this study) should be delayed until the cows are more mature.

The last column of Table 1 is the percentage of cows that calved as three-year-olds that conceived during the following breeding season. Differences in rebreeding performance were not significant and ranged from 75 percent for the Jersey-Hereford cows to 46.2 percent for Brown Swiss-Hereford cows.

The average rebreeding performance of 62.8 percent is disappointingly low. Part of this low rebreeding performance is perhaps due to the fact that one-half of the cows in each crossbred group were bred by artificial insemination. However, it probably also indicates an inadequate level of nutrition. These cows received 2 lb of 41 percent protein cottonseed cake daily from November 1 to calving. After calving, they received 5 lb daily of a 20 percent protein range cube that contained 60 percent milo. Supplementation was increased to 7 lb daily for 30 days prior to the start of breeding season. Apparently additional feed supplementation would be required to achieve a higher level of reproduction from lactating three-year-old cows.

Table 1. Reproductive performance of three-year-old cows.

Crossbred cow group[1]	No. cows exposed	Cows[2] calving %	Live calves[2] born %	Calving difficulty[3,4] %	Calving difficulty[3,4] score	Calves[2] weaned %	Cows[3] rebred %
HA	35	74.3[a]	65.7[ab]	30.8[a]	1.71[b]	65.7[ab]	57.7[a]
AH	41	75.6[a]	73.2[a]	25.8[a]	1.89[b]	73.2[a]	54.8[a]
SA	45	73.3[a]	73.3[a]	48.5[a]	2.50[a]	73.3[a]	63.6[a]
SH	27	70.4[ab]	70.4[ab]	31.6[a]	1.90[ab]	70.4[ab]	47.4[a]
BA	33	63.6[ab]	57.6[ab]	23.8[a]	1.69[b]	57.6[ab]	57.1[a]
BH	37	35.1[b]	29.7[b]	23.1[a]	1.46[b]	29.7[b]	46.2[a]
JA	42	83.3[a]	76.2[a]	11.4[a]	1.52[b]	76.2[a]	48.6[a]
JH	43	93.0[a]	88.4[a]	22.5[a]	1.65[b]	88.4[a]	75.0[a]
Total or average	303	71.9	67.7	27.1	1.79	67.7	62.8

[1] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[2] Based on number of cows exposed to breeding.
[3] Based on number of cows calving.
[4] Calving difficulty scores: 1 = no difficulty, 2 = little difficulty, 3 = moderate difficulty, 4 = major difficulty and 5 = caesarian. Percent calving difficulty are those receiving a score of 3, 4, or 5.
[a,b]Means in a column that do not share at least one common superscript are significantly different at the .05 probability level.

Table 2. Performance to weaning of calves produced by two-breed cross cows.

Crossbred	No.	Birthweight	Weaning		Preweaning	205-day weaning wt[4]	
cow group[1]	calves	lbs	conformation[2]	condition[3]	ADG (lbs/day)	lbs	% HA,
HA	23	78.1[ab]	13.2[c]	4.9[a]	1.67[b]	421[b]	101.3
AH	30	72.3[cd]	13.2[c]	4.9[a]	1.65[b]	410[b]	98.7
SA	32	77.7[abc]	13.8[a]	5.0[a]	1.94[a]	474[a]	114.1
SH	19	79.1[ab]	13.7[ab]	5.0[a]	1.84[a]	457[a]	110.0
BA	19	76.6[abc]	13.4[abc]	5.0[a]	1.91[a]	463[a]	111.4
BH	11	81.7[a]	13.5[abc]	5.0[a]	1.93[a]	476[a]	114.6
JA	32	69.7[d]	13.1[c]	4.9[a]	1.93[a]	465[a]	111.9
JH	38	73.8[bcd]	13.2[c]	5.0[a]	1.88[a]	460[a]	110.7
Total or average	204	76.1	13.4	5.0	1.84	453	

[1] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[2] Conformation score: 13 = average choice and 14 = high choice.
[3] condition score: 1 = very thin to 5 = average to 9 = very fat.
[4] Weaning weights were not adjusted for age of dam since all cows were four years old.
[a,b,c,d] Means in a column that do not share at least one common superscript are significantly different at the .05 probability level.

Table 3. Weaning weight production per crossbred cow in the breeding herd.

Crossbred cow group[1]	Pounds of calf weaned per cow exposed					
	As two-year-olds		As three-year-olds		Average	
	lbs	% HA, AH	lbs	% HA, AH	lbs	% HA, AH
HA	260	94.9	277	96.0	269	95.7
AH	288	100.5	300	104.0	294	104.6
SA	307	112.0	337	116.8	322	114.6
SH	220	80.3	322	111.6	271	96.4
BA	381	139.1	266	92.2	324	115.3
BH	305	111.3	142	49.2	224	79.7
JA	367	133.9	354	122.7	361	128.5
JH	382	139.4	407	141.1	395	140.6
Average	314		301		307	

[1] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

Performance of the three-breed cross calves sired by Brahman and Charolais bulls is presented in Table 2. The lightest calves at birth were from Jersey cross and Angus-Hereford cows (averaged 71.9 lb) and the other crossbred groups produced heavier calves ranging from 76.6 lb for Brown Swiss-Angus to 81.7 for Brown Swiss-Hereford cows.

Higher levels of lactation achieved by Simmental, Brown Swiss and Jersey cross cows resulted in more rapid calf growth rate from birth to weaning. Calves from the Hereford-Angus reciprocal crosses averaged 1.66 lb/day from birth to weaning, whereas, calves from all other crosses averaged 1.91 lb/day.

The higher preweaning gain of calves from Simmental, Brown Swiss and Jersey cross cows resulted in 205-day weaning weights that were not significantly different and averaged 466 lb which was 50 lb or 12.1 percent heavier than calves from the Hereford-Angus reciprocal cross cows. At weaning, the calves were very similar in condition score and all were acceptable in conformation (average chioce) with calves from Simmental and Brown Swiss crosses exhibiting slightly more muscling.

Comparisons among crossbred groups in total productivity for the breeding herd were made by combining the percentage of cows exposed that weaned calves with the respective weaning weights to obtain pounds of calf weaned per cow exposed in the breeding herd (Table 3). The first two columns present productivity of these crossbred groups as two-year-olds (previously reported and discussed in the 1978 Animal Science Research Report MP-103:105-111). The middle two columns represent productivity as three-year-olds and the last two columns summarizes productivity for the first two years of production.

Brown Swiss-Angus cows, which were 39.1 percent more productive than reciprocal Hereford-Angus cows as two-year-olds, were 11 lb per cow exposed or 7.8 percent less productive as three-year-olds. Although Brown Swiss-Hereford cows produced the heaviest calves at weaning, their low calf crop weaned percentage of 29.7 percent resulted in production as three-year-olds 146 lb (50.8 percent) below the reciprocal Hereford-Angus cows.

As compared to the reciprocal Hereford-Angus cows, Simmental cross cows were 41 lb (14.2 percent) and the Jersey cross cow 92 lb (31.9 percent) more productive per cow exposed to breeding. The favorable productivity of the Simmental-Hereford cows

Table 4. Crossbred cow weights and measures of cow efficiency.

Crossbred cow group[1]	No. cows	Average cow weight[2]		Calf wn. wt. ÷ cow wt.		Calf wn. wt. ÷ cow metabolic wt.	
		lbs	% HA, AH	Ratio	% HA, AH	Ratio	% HA, AH
HA	23	839[ab]	104.4	.516[d]	97.9	2.75[c]	98.7
AH	30	768[cd]	95.6	.538[cd]	102.1	2.83[c]	101.3
SA	32	878[a]	109.3	.546[bcd]	103.6	2.97[bc]	106.3
SH	19	859[ab]	106.9	.540[bcd]	102.5	2.92[bc]	104.5
BA	19	817[bc]	101.7	.579[b]	109.9	3.09[b]	110.6
BH	11	838[ab]	104.3	.578[bc]	109.7	3.10[b]	110.9
JA	32	739[d]	92.0	.644[a]	122.2	3.34[a]	119.5
JH	38	718[d]	89.4	.651[a]	123.5	3.36[a]	120.2
Total or average	204	807		.574		3.046	

[1] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[2] Average of spring weight after calving and prior to breeding and the fall weight after weaning.
[a,b,c,d] Means in a column that do not share at least one common superscript are significantly different at the .05 probability level.

as three-year-olds was probably because of the fact that as two-year-olds only 53.3 percent of them weaned a calf. Thus, nearly half of the Simmental-Hereford cows exposed to breeding for three-year-old production had not previously produced a calf and were in a very favorable physiological condition for reproduction.

Over the first two years of production, Brown Swiss-Hereford and Simmental-Hereford cows were 20.3 percent and 3.6 percent, respectively, less productive per cow exposed to breeding than Hereford-Angus reciprocal crosses. Conversely, Simmental-Angus, Brown Swiss-Angus, Jersey-Angus and Jersey-Hereford cows were 14.6 percent, 15.3 percent, 28.5 percent and 40.6 percent, respectively, more productive than the reciprocal Hereford-Angus crosses.

Larger cows require more feed for body maintenance and thus, need to wean larger calves in order to be competitive with smaller cows in efficiency of production. Table 4 presents average cow weights and some measures of cow efficiency for those cows weaning calves in each crossbred cow group. Cow weight is the average of the weight obtained in April after calving and before breeding season and the fall weight obtained on the day calves were weaned. Average cow weight over all crossbred groups was 807 lb which is 84 lb heavier than these cows were as two-year-olds. Jersey cross cows were 9.3 percent lighter than Hereford-Angus reciprocal cross cows, whereas the other crossbred cow groups ranged form 1.7 percent (Brown Swiss-Angus) to 9.3 percent (Simmental-Angus) heavier. There is no apparent reason for the rather large difference of 71 lb between Hereford-Angus and Angus-Hereford cows.

One measure of cow efficiency is the ratio of calf weaning weight to cow weight. Larger ratios are indicative of more efficient cows. On this basis, Jersey cross cows were most efficient weaning calves that weighed 64.7 percent of the cow's weight. Brown Swiss and Simmental cross cows were intermediate in efficiency, weaning calves that weighed 56.1 percent of the cow's weight; Hereford-Angus reciprocal cross cows were least efficient, weaning calves that weighed 52.7 percent of the cow's weight.

Nutritional requirements to maintain a cow of a particular size is dependent upon the metabolic body size of the animal which can be estimated as the animal's weight taken to the 0.75 power. Since differences in feed requirements among crossbred cow groups should be estimated with more precision when based on metabolic cow size, the ratio of calf weaning weight to cow metabolic body weight was calculated as a second measure of cow efficiency. On this basis, Jersey cross cows were most efficient (19.9 percent more efficient than Hereford-Angus reciprocal cross cows) and the Brown Swiss and Simmental cross cows were intermediate in efficiency (8.1 percent more efficient than Hereford-Angus reciprocal cross cows). These comparisons of cow efficiency were very similar to that obtained for these crossbred cow groups as two-year-olds.

These data suggest some relatively large differences in three-year-old cow productivity among the various crossbred cow groups. Comparisons in productivity at any one age should be considered with some caution and final judgement should be reserved until productivity can be averaged over several years through maturity.

Comparisons of Lactational Performance Among Various Four-Year-Old Crossbred Cow Groups

C. G. Belcher, R. R. Frahm,
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Story in Brief

Milk yield and composition were estimated monthly from April through September of 1978 for 71 four-year-old cows of eight crossbred groups (Hereford x Angus (HA), Angus x Hereford (AH), Simmental x Angus (SA), Simmental x Hereford (SH), Brown Swiss x Angus (BA), Brown Swiss x Hereford (BH), Jersey x Angus (JA) and Jersey x Hereford (JH)).

Milk yields were estimated by machine milkout preceded by a 1.5 mg injection of a synthetic oxytocin. Calves were separated from their dams for six hrs, allowed to suckle, then separated again for six, nine or 12 hrs before milking.

Overall cows produced 16.29 lb/day of milk testing 4.9 percent butterfat, 3.30 percent protein and 13.30 percent total solids. JA and BA cows produced the most milk (17.95 lb/day), followed by JH, BH, SA and SH crosses (averaged 16.20 lb/day). The HA and AH cows produced the least milk (14.38 lb/day). Differences among crossbred cow groups for lbs of butterfat produced per day and butterfat percent were not significant. Milk butterfat content ranged from 5.1 percent for JA cows to 4.6 percent for BA cows. Milk protein content varied from 3.44 percent for Jersey crosses to 3.21 percent for Brown Swiss crosses. Milk from Jersey crosses, AH and HA cows had the highest total solids (13.28 percent) followed by JA, SH and BH cows (averaged 12.92 percent) while BA cows produced milk lowest in total solids (12.49 percent).

Introduction

Yield and composition of milk produced by beef cows under range conditions is a major factor influencing calf growth rate and weaning weights. Consequently, estimating the yield and composition of milk produced by various breed types involved in beef production is important to characterize biological differences that exist among breeds and crossbreds. Such information will aid producers in selecting breeds for crossbreeding programs that will optimize production efficiency for a given feed supply and management system.

The objectives of this study were (1) to compare milk yield and composition of various crossbred cow groups and (2) to compare the effect of six, nine and 12-hr time intervals of cow-calf separation prior to milking on the estimates of 24-hr milk yield and composition. This study is a portion of an extensive research program presently in progress at the Oklahoma Agricultural Experiment Station comparing lifetime productivity of various two-breed cross cows mated to a bull of a third breed.

Experimental Procedures

The data used in this study were obtained from 71 four-year-old crossbred cows and their calves. In the spring of 1978, a random sample of four-year-old crossbred cows (nine from each of eight crossbred cow groups with the exception of Simmental x Hereford which only had eight cows available) were identified for estimating lactational performance. The eight crossbred cow groups involved were Hereford x Angus

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(HA), Angus x Hereford (AH), Simmental x Angus (SA), Simmental x Hereford (SH), Brown Swiss x Angus (BA), Brown Swiss x Hereford (BH), Jersey x Angus (JA) and Jersey x Hereford (JH). Half of the calves produced by each cow group was sired by Charolais bulls and the other half by Limousin bulls.

Calves were born mostly in February and March with a few born in late January or early April. The calves remained with their dams on native and bermuda grass pasture until weaning at an average age of 205 days.

Lactational performance was determined monthly from April through September by machine milkout. In order to determine the effect of cow-calf separation time on 24-hr milk yield estimates, three cows of each crossbred group were allocated to one of three cow-calf separation time periods: six, nine or 12 hrs. Thus, there were a total of 24 cows assigned to each time group with the exception of the nine-hr separation period which had only 23 cows.

Because of time and labor requirements for milking range cows by machine it was necessary to divide the herd and do the milking on two different days. One group of 36 cows (balanced as nearly as possible by calf separation time and crossbred cow group) were milked one day per month and the other group of 35 cows milked the following week. Cows were milked out during the last two week of each month from April through September.

Prior to milking, calves were separated from the cows six hrs, placed with their dams to suckle and separated again for six, nine or 12 hrs, depending on the respective calf separation time group. Approximately 15 minutes prior to milking, cows were given an intramuscular injection of 10 to 30 mg of the tranquillizer ace promazine. Immediately prior to milking, cows were injected with 1.5 mg of syntocin, a synthetic oxytocin, in the jugular for milk letdown. Cows were milked out by a portable vacuum pump milking unit. Milking time per cow varied from five to 10 minutes. Each cow's udder was stripped out by hand to assure a complete milkout. The milk was weighed and two samples taken for milk composition analysis.

Samples for butterfat content were transfered to the DHIA laboratory at Oklahoma State University for analysis by a milk-o-tester. Protein content was determined by the UDY method and total solid analysis was done by over-drying samples in a 100° C oven for four hours. All milk composition estimates were completed within four days of each milking.

Results and Discussion

Table 1 presents adjusted means for milk traits averaged over the six months for each crossbred cow group. Twenty-four hr milk production was highest for JA (18.2 lb/day) and BA (17.7 lb/day) cows followed by JH, BH, SA and SH cows (averaged 16.2 lb/day). The AH and HA cows were lowest in milk yield and averaged 14.4 lb/day.

Differences between crossbred cow groups for lb of butterfat per day and percent butterfat were not significant. Overall the cows produced .79 lb/day of butterfat and ranged from .88 lb/day for Jersey crosses to .71 lb/day for HA cows. Butterfat percent varied from 5.1 percent for JH to 4.6 percent for BA cows.

Milk protein content was highest for Jersey crosses (3.44 percent), intermediate for SA, SH, AH and HA cows (averaged 3.28 percent) and lowest for Brown Swiss crosses (3.21 percent). Milk from JH cows had the highest percent of total solids (14.3 percent) followed by milk from JA, HA and AH cows (averaged 13.6 percent) and was lowest for Simmental and Brown Swiss crosses (averaged 12.8 percent).

Table 2 presents adjusted means for milk traits by cow-calf separation time. As time of cow-calf separation increased, estimates of 24-hr milk yield decreased. Milk yield estimates for a 24-hr period were 2.27 lb higher for cows in the six-hr separation group than from cows in the 12-hr cow-calf separation group. The estimated daily milk

Table 1. Adjusted means for milk traits for each crossbred cow group.

Crossbred cow groups[1]	No. of cows	Milk yield (lb/day)	Butterfat (lb/day)[2]	Butterfat (%)[2]	Total solids (%)	Protein (%)
HA	9	13.96^{c}	.71	4.97	13.68^{ab}	3.29^{bc}
AH	9	14.79^{bc}	.75	5.01	13.56^{bc}	3.26^{bc}
SA	9	16.18^{abc}	.82	4.97	12.90^{cd}	3.28^{bc}
SH	8	15.30^{abc}	.73	4.73	12.95^{cd}	3.28^{bc}
BA	9	17.68^{a}	.82	4.62	12.49^{d}	3.19^{c}
BH	9	16.45^{abc}	.79	4.83	12.91^{cd}	3.22^{c}
JA	9	18.21^{a}	.88	4.83	13.57^{bc}	3.37^{ab}
JH	9	16.87^{ab}	.88	5.10	14.30^{a}	3.51^{a}
Overall	71	16.29	.79	4.88	13.30	3.30

^{a,b,c,d} Means in the same column that do not share at least one superscript in common are significantly different (P<.05).

[1] A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey.

[2] Overall F-test not significant (P<.05).

Table 2. Adjusted means for milk traits by cow-calf separation time prior to milking.

Separation time	No. of cows	Milk yield (lb/day)	Butterfat (lb/day)	Butterfat (%)	Total solids (%)	Protein (%)[1]
6 hours	24	17.33^{a}	.87^{a}	4.98^{a}	13.57^{a}	3.31
9 hours	23	16.16^{ab}	.81^{a}	4.96^{a}	13.31^{ab}	3.30
12 hours	24	15.06^{b}	.71^{b}	4.70^{b}	13.00^{b}	3.27

[1] Overall F-test not significant (P<.05).
^{a,b} Means in the same column that do not share at least one superscript in common are significantly different (P<.05).

Table 3. Phenotypic correlations between milk traits and calf performance.

Milk trait	Calf ADG (birth to weaning)	205-day weaning
24 hour milk yield	.291*	.165
24 hour butterfat yield	.205+	.192
Butterfat percent	−.045	.206+
Total solids	−.089	.046
Protein	−.335**	−.119

+,*,** Correlations significantly different from zero at the .10, .05 and .01 probability levels, respectively.

yield from the nine-hr separation group was intermediate between the six- and 12-hr separation groups. These data suggest that more milk is produced in the first six hr of separation time than the latter six hours.

Butterfat and total solid content of the milk also exhibited a decreasing pattern from the six-hr to 12-hr separation groups. Milk obtained from cows in the six-hr separation group was higher in lb of butterfat (+.16 lb/day), butterfat percent (+.28 percent) and total solids percent (+.57 percent) than estimates from milk of cows in the 12-hr separation group. Nine-hr group estimates were intermediate. Time of cow-calf separation did not significantly affect protein content of the milk in this study. These data suggest that it may be important to consider time of cow-calf separation when estimating milk yields and milk composition of beef cattle.

Table 3 relates lactational performance of the cow to her calf's growth performance by phenotypic correlations. A moderate correlation was observed between 24-hr milk yield and calf average daily gains (.29) while a negative correlation (−.34) was estimated between protein percent of the milk and calf average daily gain. Other correlations between milk traits and calf performance were small and not significant.

These data suggests some relatively large differences between crossbred cow groups in milk yield and milk composition. It also suggests some differences in estimated milk yield and composition due to the time period of cow-calf separation allowed before milking. Consequently the length of the calf separation period should be considered in designing studies to determine lactational performance of range cows.

Factors Affecting Calving Difficulty and the Influence of Pelvic Measurements on Calving Difficulty in Percentage Limousin Heifers

D. R. Belcher and R. R. Frahm

Story in Brief

Pelvic measurements were taken on 1,426 half (1/2) and three-quarter (3/4) Limousin heifers ranging from 354 to 481 days of age and a calving difficulty score was determined for 918 heifers observed during calving.

Factors significantly affecting calving difficulty were sex of calf, sire of calf, calf birth weight, age of heifer at first calving and pelvic size. Male calves from 1/2 Limousin heifers were 2.4 lb heavier, gestated .62 days longer and resulted in 18 percent more births requiring assistance than female calves. Male calves from 3/4 heifers were 5.4 lb heavier, gestated 1.45 days longer and resulted in 28 percent more births requiring assistance than female calves. Calves born unassisted were 6.7 lb lighter than those that required assistance. Heifers that calved unassisted had 7.4 sq cm larger pelvic areas and were 5.7 days older at calving than heifers requiring assistance.

Of the 1/2 Limousin heifers with small pelvic areas (121 to 164 sq cm), 15 percent calved unassisted compared to 69 percent for heifers with large pelvises (208 sq cm or larger). Heifers with small pelvises required more than 85 percent assistance when calves weighed more than 65 lb. Heifers of intermediate pelvic size (165 to 207 sq cm) required limited calving assistance when calves weighed less than 85 lb. Only heifers with large pelvises (208 to 250 sq cm) appeared capable of having calves weighing more

than 85 lb at birth without excessive calving problems. Implications were that pelvic measurements could be effective as a management tool to aid in reducing calving problems.

Introduction

Calf death loss represents a severe economic loss to cow-calf producers. Research has shown that the major calf loss occurs at or shortly after birth and calving difficulty is a primary cause of early calf mortality. Futhermore, studies have shown that heifers experiencing difficulty at calving have poorer reproductive performance the following breeding season than heifers not experiencing calving difficulty.

Reduction in the amount of calving difficulty and subsequently lower calf mortality would be of economic value to the beef herd. Thus, it would be highly desirable to identify factors associated with calving difficulty. Such information could be beneficial in determining procedures to identify and cull heifers with a high likelihood of being difficult calvers and developing management techniques to minimize calving problems in the breeding herd.

Research has generally shown that heifers with small pelvic openings have a higher rate of calving difficulty than heifers with larger pelvic openings. Although a significant association exists between pelvic size and calving difficulty, use of pelvic measurements to predict calving difficulty has had limited success.

The objectives of this study were (1) to identify factors most highly associated with calving difficulty and (2) to evaluate the relationship between pelvic measurements taken on heifers prior to breeding and subsequent calving performance.

Experimental Procedures

Data utilized in this study involved records of 1,426 percentage Limousin heifers produced in an upgrading program on a Colorado ranch.

Limousin bulls were mated by artificial insemination (AI) to primarily Hereford, Hereford x Angus and Angus cows to produce half Limousin calves in the spring of 1972, 1973 and 1974. Half (1/2) Limousin heifers from these matings were retained in the herd and mated AI to produce three-quarter Limousin calves in the spring of 1974, 1975, 1976 and subsequent years. Three-quarter (3/4) Limousin heifers from these matings were retained in the herd and used in the upgrading program to produce seven-eighths Limousin calves.

Heifers were under similar management each year. Heifers ran with their dams until weaning and following weaning were placed on pasture and managed to be of adequate size for breeding at approximately 15 months of age. Averaged over years, heifers gained 1.53 lb per day from weaning to breeding and weighed 684 lb at one year of age.

Pelvic measurements were taken each year just prior to the breeding season with all heifers in a year group being measured the same day. Pelvic measurements were adjusted to a standard age of 450 days (15 months) for all heifers.

Heifers were closely watched during the calving season and given a subjective calving score by the herdsman of 1 = no assistance, 2 = easy pull, 3 = hard pull, 4 = caesarean or 5 = abnormal presentation.

Records were edited to include only those heifers that had pelvic measurements and subsequent calving performance. Records with a calving score of 5 were also deleted from the analysis.

Results and Discussion

Heifers ranged from 354 to 481 days of age at the time pelvic measurements were taken. Estimates of pelvic growth over this period were calculated and used to adjust pelvic size of all heifers to a constant age of 450 days. Average daily growth was .011 cm per day for pelvic height, .014 cm per day for pelvic width and .331 sq cm per day for pelvic area.

Factors used in the analysis of calving difficulty were breed of heifer, sire of heifer, sire of heifer's first calf, sex of calf, calf birth weight, gestation length, age of heifer at first calving and pelvic size. Those factors found to significantly influence calving difficulty were sire of calf, sex of calf, calf birth weight, age of the heifer at calving and pelvic size.

Average birth weight and gestation length of male and female calves are presented in Table 1 by calving difficulty scores for each breed of heifer. Male calves from 1/2 Limousin heifers averaged 2.4 lb heavier at birth and experienced 18 percent more calving difficulty than female calves. Sixty-six percent of the heifers having male calves experienced some calving difficulty while only 48 percent of those heifers having female calves required assistance. Calves from 1/2 Limousin heifers that calved unassisted were 6.8 lb lighter at birth than calves from heifers having difficulty at calving (74.3 vs 81.1 lb). Birthweight of calves increased by 4.4, 3.0 and 1.4 lb for each increment of increased calving difficulty score from 1 to 4, respectively. These data would suggest that at heavier birth weights, smaller increases in calf birth weight were required to cause an increased level of calving difficulty. Some of the heavier birth weights and subsequent increased calving difficulty was likely due to the increased gestation lengths observed for each increasing level of calving difficulty.

The same general patterns were observed for 3/4 Limousin heifers. Male calves averaged 5.43 lb heavier at birth and resulted in 28 percent more calving difficulty than female calves and had 1.45 days longer gestation. Calves from 3/4 Limousin heifers that calved unassisted were 6.5 lb lighter than calves from heifers that required assistance. Although the same pattern of birth weight and gestation length differences between calving scores was observed, differences were inconsistent probably due to limited observations in each calving score category.

The average adjusted pelvic measurements and average age at first calving are presented in Table 2. In general, pelvic measurements of 1/2 and 3/4 Limousin heifers that calved unassisted were larger than pelvic measurements of heifers experiencing calving difficulty and those heifers that had difficulty at calving were younger.

Half Limousin heifers that calved unassisted had pelvic areas 5.6 sq cm larger than heifers requiring only slight assistance. Heifers requiring minor assistance had 5.2 sq cm larger pelvic areas than those requiring major assistance and the difference in pelvic area of heifers requiring major assistance or caesarean was 5.1 sq cm. The difference in pelvic area of 3/4 Limousin heifers that required no assistance, minor assistance or major assistance was less than that observed in 1/2 Limousin heifers averaging only 3.26 sq cm. None of the 3/4 Limousin heifers required a caesarean.

To better observe the relationship between pelvic size and calving difficulty, heifers were placed into categories based on pelvic area. Categories were determined by finding the total range in pelvic area from smallest to largest and dividing this range into thirds (small, intermediate and large). However, 83 percent of the heifers had pelvises in the intermediate range of 165 to 207 sq cm. Consequently, this category was subdivided into halves to give a low and high intermediate group. Thus, there were four pelvic area categories: small = 121 to 164 sq cm, low intermediate = 165 to 186 sq cm, high intermediate = 187 to 207 sq cm and large = 208 to 250 sq cm.

The percentage of 1/2 Limousin heifers within each pelvic category that had a calving score of 1, 2, 3, or 4 is presented in Figure 1. The percentage of heifers that calved unassisted continually increased for each larger pelvic area category ranging from 15 percent for heifers with small pelvises (121 to 164 sq cm) to 69 percent for heifers with large pelvic areas (208 to 250 sq cm).

Eighty-five percent of the heifers with small pelvic areas required some degree of calving assistance and 45 percent required major assistance or caesarean. Of the heifers

Table 1. **Average calf birth weight and gestation length for each calving difficulty score.**

Breed of heifer (N)		Calving difficulty score[1] 1	2	3	4
1/2 Limousin heifers (706)					
Calf birth weight	male	74.9	79.3	82.1	83.8
(lb)	female	73.6	77.9	81.3	82.3
Gestation length	male	287.3	287.9	289.6	291.0
(days)	female	286.9	288.1	288.7	289.0
3-4 Limousin heifers (112)					
Calf birth weight	male	70.0	74.4	74.2	-
(lb)	female	65.4	68.4	79.8	-
Gestation length	male	288.0	288.5	287.8	-
(days)	female	287.1	284.7	287.3	-

[1] Calving scores were 1 = unassisted, 2 = easy pull, 3 = hard pull and 4 = caesarean.

Table 2. Average pelvic height, width, area and average age at calving for each calving difficulty score.

Breed of heifer (N)	Calving difficulty score[1] 1	2	3	
1/2 Limousin heifers (706)				
Adusted pelvic height (cm)	14.7	14.6	14.3	4.2
Adjusted pelvic width (cm)	13.0	12.7	12.5	2.2
ADJUSTED PELVIC AREA (sq cm)	190.3	184.7	179.5	4.4
Age at first calving (days)	726.8	726.5	722.5	6.4
3/4 Limousin heifers (112)				
Adjusted pelvic height (cm)	14.7	14.6	14.6	-
Adjusted pelvic width (cm)	12.6	12.6	12.3	-
ADJUSTED PELVIC AREA (sq cm)	186.1	184.4	179.6	-
Age at first calving (days)	757.9	755.4	747.5	-

[1] Calving scores were 1 = unassisted birth, 2 = easy pull, 3 = hard pull and 4 = caesarean.

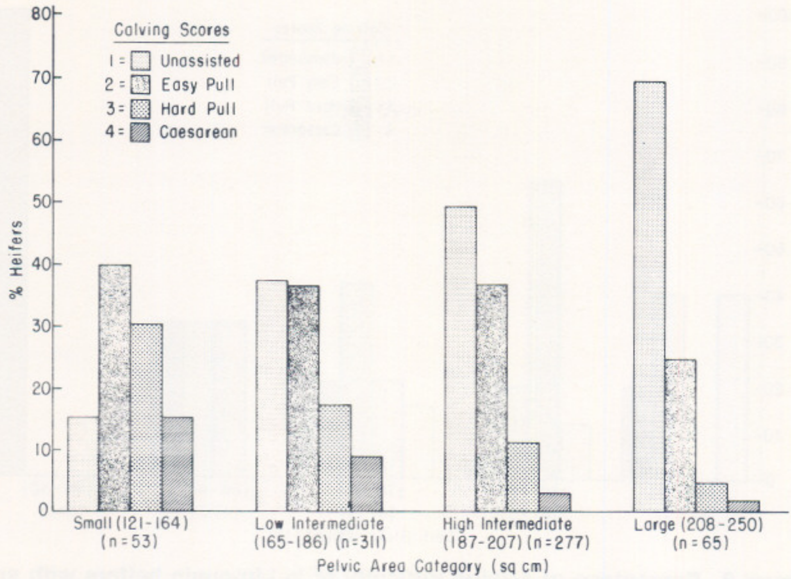


Figure 1. Percentage of calving difficulty of ½ Limousin heifers for each pelvic area category.

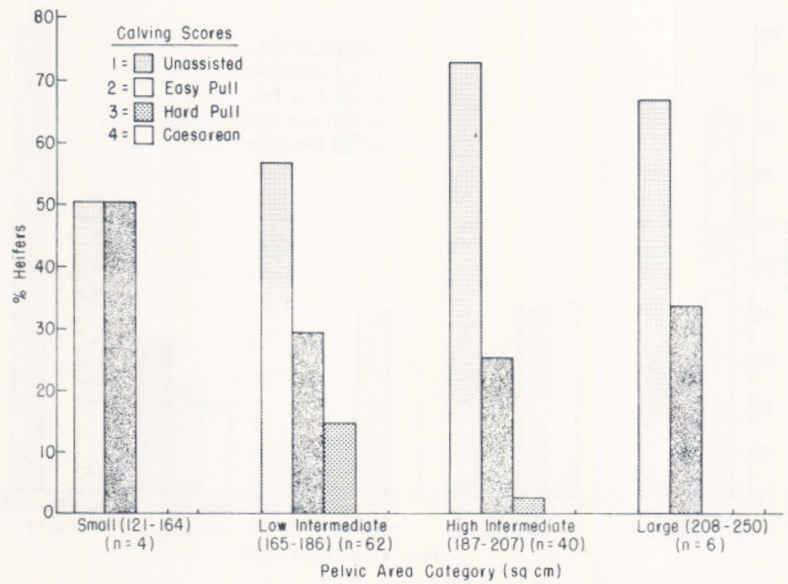


Figure 2. Percentage of calving difficulty of ¾ Limousin heifers for each pelvic area category.

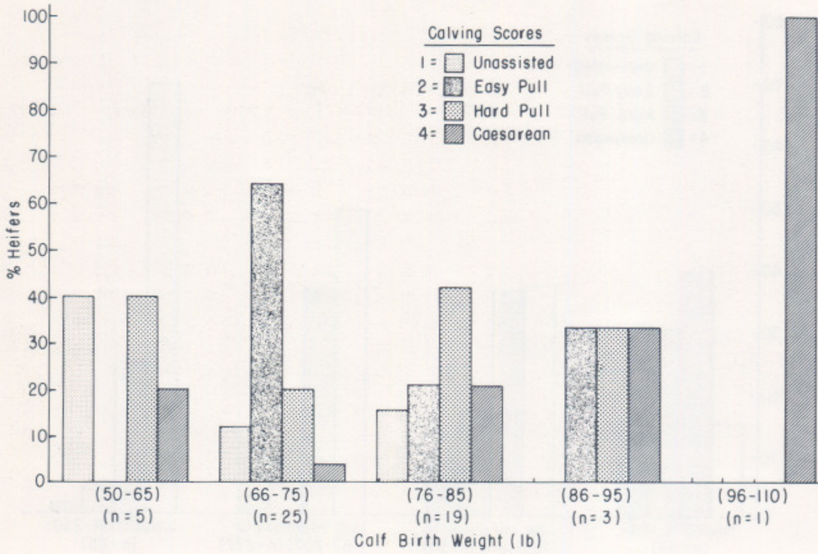


Figure 3. Percentage of calving difficulty of ½ Limousin heifers with small pelvic areas (121-164 sq cm) by calf birth weight.

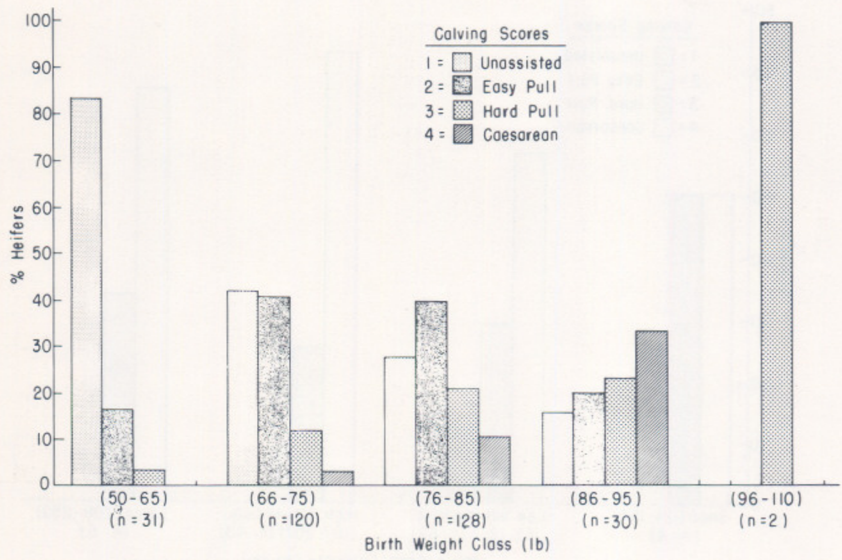


Figure 4. Percentage of calving difficulty of ½ Limousin heifers with low intermediate pelvic areas (165-186 sq cm) by calf birth weight.

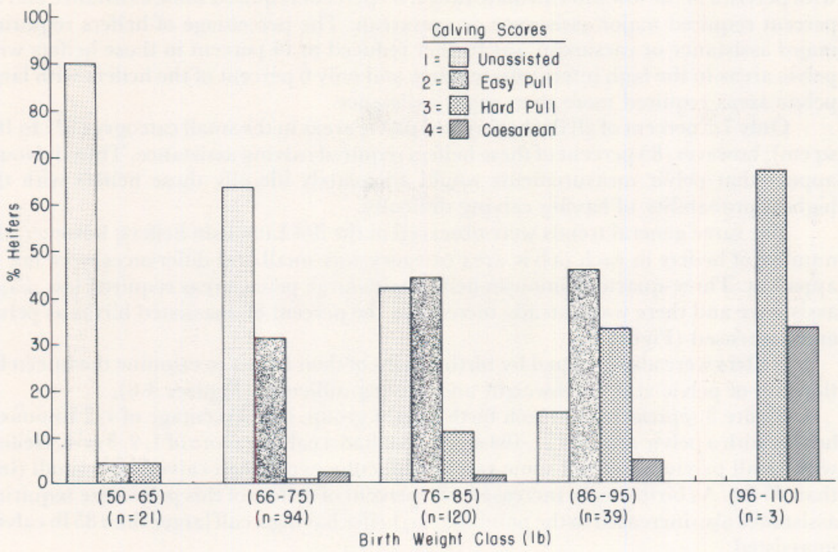


Figure 5. Percentage of calving difficulty of ½ Limousin heifers with high intermediate pelvic areas (187-207 sq cm) by calf weight.

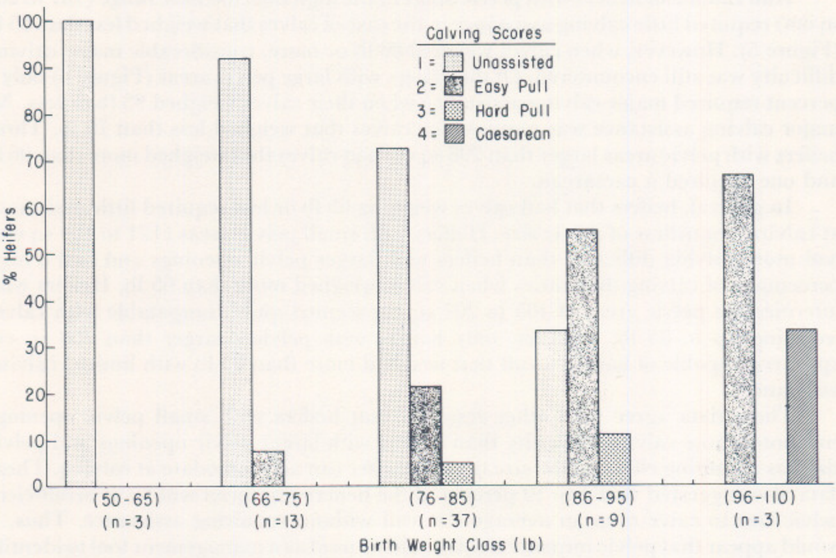


Figure 6. Percentage of calving difficulty of ½ Limousin heifers with large pelvic areas (208-250 sq cm) by calf birth weight.

with pelvises in the low intermediate range, 63 percent required some assistance and 26 percent required major assistance or caesarean. The percentage of heifers requiring major assistance or caesarean was further reduced to 14 percent in those heifers with pelvic areas in the high intermediate range and only 6 percent of the heifers with large pelvic areas required more than slight assistance.

Only 7.5 percent of all the heifers had pelvic areas in the small cateogry (121 to 164 sq cm); however, 85 percent of these heifers required calving assistance. Thus, it would appear that pelvic measurements would adequately identify those heifers with the highest probability of having calving difficulty.

The same general trends were observed in the 3/4 Limousin heifers; however, the number of heifers in each pelvic area category was small and differences were not as apparent. Three-quarter Limousin heifers with large pelvic areas required less major assistance and there was a steady increase in the percent of unassisted births as pelvic area increased (Figure 2).

Heifers were also grouped by birth weight of their calves to examine the interrelationship of pelvic size, birthweight and calving difficulty (Figures 3-6).

Figure 3 represents, for each birth weight group, the percentage of 1/2 Limousin heifers with a pelvic area of 121-164 sq cm that had a calving score of 1, 2, 3 or 4. Heifers with small pelvic areas had some calving difficulty even when calves were small (less than 65 lb). As birthweight increased, the percent of heifers of this pelvic size requiring assistance also increased to the point that no heifer having a calf larger than 85 lb calved unassisted.

Figure 4 represents 1/2 Limousin heifers with pelvic areas in the low intermediate range (165 to 186 sq cm). Heifers that had calves weighing 75 lb or less required little major assistance while a high percentage of heifers that had calves weighing more than 85 lb required major assistance or caesarean. Heifers having calves that weighed from 76 to 85 lb were intermediate in amount of calving difficulty.

Half Limousin heifers with pelvic areas in the high intermediate range (187 to 207 sq cm) required little calving assistance in the case of calves that weighed less than 85 lb (Figure 5). However, when calves weighed 86 lb or more, considerable major calving difficulty was still encountered. Of the heifers with large pelvic areas (Figure 6) only 5 percent required major calving assistance when their calves weighed 95 lb or less. No major calving assistance was required for calves that weighed less than 75 lb. Three heifers with pelvic areas larger than 208 sq cm had calves that weighed more than 96 lb and one required a caesarean.

In general, heifers that had calves weighing 65 lb or less required little assistance at calving regardless of pelvic size. Heifers with small pelvic areas (121 to 164 sq cm) had more calving difficulty than heifers with larger pelvic openings and had a high percentage of calving difficulties when calves weighed more than 65 lb. Heifers with intermediate pelvic areas of 165 to 207 sq cm seemed quite compatable with calves weighing up to 85 lb; however, only heifers with pelvises larger than 208 sq cm appeared capable of having a calf that weighed more than 85 lb with limited calving assistance.

These data agree with other research that heifers with small pelvic openings encounter more calving difficulty than heifers with larger pelvic openings and pelvic size has a limiting effect on the size of calf a heifer can accommodate at calving. These data also suggested that 5 to 10 percent of the heifers produced will be of insufficient pelvic size to calve even an average size calf without requiring assistance. Thus, it would appear that pelvic measurements could be used as a management tool to identify those heifers with a high risk of having calving difficulty. These heifers could be culled from the breeding herd. However, if it was desired to keep them in spite of their expected calving problem, they could be mated to bulls known to sire smaller calves in order to minimize calving problems.

Comparison of Feedlot Performance and Carcass Traits of Charolais and Brahman Sired Three-Breed Cross Calves

S. H. Peterson, R. R. Frahm
and L. E. Walters

Story in Brief

Feedlot performance and carcass traits were compared between Charolais and Brahman sired three-breed cross calves. Data were obtained on 251 calves (127 heifers and 124 steers). All calves were placed on a self-fed finishing ration immediately after weaning and slaughtered when each animal attained an estimated low choice carcass grade. Feedlot performance favored calves sired by Charolais. Charolais sired calves gain .31 lb/day more rapidly and were 91 lb heavier at slaughter.

Significant sirebreed differences were also found for carcass traits. Charolais sired calves were 39 lb heavier in carcass weight, had a .07 lb advantage in carcass weight per day of age, were lower in dressing percent by 1.2 percent, had .15 inches less fat cover, .33 percent less KHP fat, 1.99 square inches more REA and 2.05 percent higher estimated cutability than Brahman sired calves. Tenderness scores were similar and quite acceptable for both sirebreeds. Based on actual performance, Charolais cross calves would return $16.46 more per head above feedlot costs than Brahman cross calves.

Introduction

Research studies have consistently shown that systematic crossbreeding systems can effectively increase the efficiency of producing beef. Over half of this increase is due to utilizing a crossbred cow. Consequently, an extensive research program is currently in progress at the Oklahoma Agricultural Experiment Station to evaluate the productivity of various two-breed cross cows when mated to bulls of a third breed. It is important to the overall efficiency of beef production that the three-breed cross calves produced in such a system have adequate feedlot performance and carcass merit. The purpose of this study was to compare Charolais and Brahman as sirebreeds with regard to feedlot performance and carcass traits of such three-breed cross calves.

Experimental Procedure

Eight different two-breed cross cow groups (Hereford x Angus, Angus x Hereford, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus, Jersey x Hereford) were mated to Charolais and Brahman bulls to produce three-breed cross calves in Spring of 1976 and 1977. Cows were three- and four-year-olds with the four-year-olds being bred only to Charolais. Three Brahman bulls and four Charolais bulls were used for the 1976 calf crop. Three of the original Charolais bulls, six new Charolais bulls and three new Brahman bulls produced the 1977 calf crop. Breeding season was from May 1 to July 15 each year, and the

In cooperation with USDA, Science and Education Administration, Southern Region.

calves were born from February to early April. Calves remained with their dams on native and bermuda grass pastures at the Lake Carl Blackwell Research Range until weaned at an average age of 205 days.

Following weaning, all calves were shipped to the Southwestern Livestock and Forage Research Station at El Reno and placed immediately in the feedlot. Each kind of three-breed cross calves (steers and heifers combined) were randomly assigned to a pen in the feeding barn and self-fed the finishing ration shown in Table 1. Each animal was removed and sent to slaughter when an estimated low choice grade was attained. Feedlot performance and carcass traits were evaluated on 251 calves (154 Charolais and 97 Brahman crosses, respectively). A sample of 55 Charolais and 46 Brahman cross steer carcasses were taken to the Oklahoma State University Meat Laboratory for detailed carcass evaluation. Tenderness estimates were obtained by subjecting one inch core samples from oven-broiled steaks to Warner-Bratzler shear procedures.

Results and Discussion

Interactions between sirebreed and year were significant for several traits measured. However, in all traits but two, the sirebreeds ranked the same and only the magnitude of the differences varied between the two years. Sirebreeds did change rank for slaughter age and starting weight. In 1976, Brahman crossbreds went on test at a heavier weight and were older at slaughter. In 1977, the opposite was true. Both the heavier starting weight and the older slaughter age were probably influenced by the sample of bulls used within each breed each year and the average breeding date of the crossbred cows in the respective sirebreed groups.

Feedlot performance for steers and heifers sired by Brahman and Charolais bulls are presented in Table 2. Performances have been averaged over two years and over crossbred cow groups. Charolais sired calves significantly outgained Brahman sired calves by .31 lb/day and were 91 lb heavier at slaughter. Although not significant, on the average Charolais cross calves were 10 lb heavier in initial weight and were in the feedlot two days less than Brahman sired calves. Sirebreeds differed significantly for feed efficiency with Charolais crosses requiring .34 less lb of feed per lb of gain than Brahman crosses. It should be noted that the winter feeding periods in these two years were characterized by colder temperatures and more snow than is usual for central Oklahoma, thus explaining in part, the somewhat low average daily gains.

Carcass traits for steers and heifers sired by Brahman and Charolais bulls are presented in Table 3. Since Charolais sired calves were 91 lb heavier at slaughter, carcass weights were heavier and carcass weight per day of age was superior to Brahman sired calves, even though Brahman cross calves had 1.2 percent higher dressing percentage.

Carcasses of calves produced by Charolais bulls had .15 inches less external fat over the loin eye and .33 percent less kidney, heart and pelvic fat (KHP). On the

Table 1. Finishing ration for cross-bred calves.

Ingredient	Percent in ration
Corn	39
Milo	39
Alfalfa	8
Cottonseed hulls	4
Molasses	5
Supplemental pellets[1]	5

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

Table 2. Feedlot performance of three-breed cross calves sired by Charolais and Brahman bulls.

Traits	Sirebreed (steers)		Sirebreed (heifers)		Difference averaged over both sexes
	Charolais	Brahman	Charolais	Brahman	(Charolais-Brahman)
Number of animals	72	52	82	45	- -
Initial weight, lb	475	463	455	448	10
Days in feedlot	261	255	244	255	−2
ADG, lb/day	2.43	2.44	2.27	1.84	.31**
Final weight, lb	1103	1022	1006	904	91**
Feed efficiency, lbs feed/lb gain[1]	7.91	8.25	7.91	8.25	−.34**

[1]Steers and heifers of each three-breed cross group were together in a pen, thus feed efficiency could not be measured for each sex.
**Differences are significant at the .01 probability level.

Table 3. Carcass traits of three-breed cross calves sired by Charolais and Brahman bulls.

Traits	Sirebreed (steers)		Sirebreed (heifers)		Difference averaged over both sexes
	Charolais	Brahman	Charolais	Brahman	(Charolais-Brahman)
Number of animals	72	52	82	45	- -
Slaughter age, days	471	450	448	454	7
Carcass weight, lb	693	660	634	589	39**
Carcass weight per day of age	1.47	1.47	1.42	1.28	.07**
Dressing percent	62.7	63.9	62.9	64.1	−1.20**
Single fat thickness, in	.42	.58	.46	.60	−.15**
KHP, %	3.12	3.37	3.14	3.58	−.33**
Marbling score[1]	5.00	5.22	5.17	5.52	−.27
Carcass grade[2]	9.9	10.2	10.0	10.6	−.42*
REA, sq in	13.30	11.26	12.46	10.52	1.99**
Cutability, %1	50.5	48.4	50.2	48.2	2.05**
Tenderness, lb[3]	16.9	16.2	- -	- -	.7

[1]Marbling score equivalents: 4 = slight, 5 = small.

[2]Grade equivalents: 9 = high good, 10 = low choice and 11 = average choice.

[3]Tenderness measured as lb of Warner-Bratzler shear force. Only 55 Charolais and 46 Brahman cross steers were evaluated for this trait.

**Differences are significant at the .01 probability level.

*Difference is significant at the .05 probability level.

Table 4. Economic analysis of performance differences between Charolais and Brahman sired three-breed cross calves.

	Charolais	Brahman
Feed cost[1], $	203.01	182.67
Overhead[2], $	118.44	119.85
Total	321.45	302.52
Carcass weight, lb	663	625
Yield grade	3	3
Quality grade	Choice	Choice
Price, selling Yield and grade, $ per cwt[3]	93.13	93.13
Return above feedlot cost, $	296.00	279.54
Break-even feeder price, $ per cwt	63.66	61.44

[1]Based on: $3.80/cwt milo, $2.60/bu corn, $80/ton alfalfa, $70/ton cottonseed hulls, $90/ton molasses, $150/ton supplemental pellets.
[2]Includes $.22 per day interest and $.25 per day yardage.
[3]Carlot beef price quotations, Texas panhandle and western Oklahoma, Jan. 10, 1979 (average of heifer and steer quotations).

average ribeye area (REA) for the Charolais cross calves was 1.99 square inches larger than for Brahman crosses. Charolais cross calves were 2.05 percent higher in cutability estimates and although not significant, Brahman cross carcasses had slightly more marbling. The average carcass grade of the two sirebreed groups was essentially the same (9.95 vs 10.38 for Charolais and Brahman, respectively). The intent was to slaughter each animal as it attained a low choice carcass grade, and the small differences in carcass grade reflects the failure of personnel being able to predict carcass grade of the live animal with the same degree of accuracy for the various groups of cattle evaluated. Specifically, the Brahman cross heifers should have been slaughtered a few days earlier.

Tenderness as measured by Warner-Bratzler shear force, was similar for both sirebreeds (16.9 vs 16.2, Charolais and Brahman crosses, respectively) and within the range of consumer acceptability.

An economic evaluation of the feedlot performance of Charolais and Brahman sired calves is presented in Table 4. Feed costs, overhead costs and carcass sale value were based on prevailing prices for January 10, 1979, in the Oklahoma panhandle feedlot area. From this table, it can be seen that Charolais crossbred calves returned $16.46 more above feedlot expenses than Brahman sired calves and would, on that basis, be worth $2.22 per cwt more as feeder calves.

Although these Brahman and Charolais bulls were mated to a diverse group of crossbred cows, calves produced were quite uniform in conformation and condition. These data would suggest that either sirebreed could be successfully utilized in a terminal cross mating system. This is especially apparent when noting how close the performance of Charolais cross heifers was to that of Charolais cross steers. Since heifers will not be selected for replacement from a terminal cross system, it is important that they perform acceptably from the standpoint of feedlot performance and carcass desirability.

Endocrine Function of Bulls Exposed to Elevated Ambient Temperature

J. E. Minton, R. P. Wetteman,
D. C. Meyerhoeffer and E. J. Turman

Story in Brief

Eight Angus bulls were used to evaluate the effect of elevated ambient temperature on serum testosterone concentration. Bulls were placed in temperature controlled chambers and cannulae were inserted into the jugular veins 15 hr before each of three bleeding periods. Heat stressed and control bulls were exposed continuously to 34 ± 1 C and 22 ± 1 C, respectively. Respiratory rates and rectal temperatures were greater in heat stressed than control bulls. Average serum testosterone concentrations and frequency, magnitude and duration of testosterone secretory spikes were similar for both treatments. Thus, either heat stress does not alter androgen biosynthesis or adjustments in metabolism or disposition of androgens occur during heat stress so blood concentrations do not reflect testicular synthesis.

Introduction

Exposure of farm animals to elevated ambient temperature results in a number of detrimental effects on reproductive performance. In the male, perhaps the most pronounced effect is the reduction in spermatogenesis.

Several studies have been conducted to investigate the effect of elevated temperature on testicular function in bulls. In these studies, the influence of heat stress on accessory sex organs, seminiferous epithelium and various semen characteristics were evaluated. However, the effects of elevated temperature on testicular endocrine function in bulls has not been clearly defined.

This study was designed to assess blood serum testosterone concentration in bulls exposed to elevated ambient temperature. Since serum testosterone concentrations vary greatly in a 24-hr period, a frequent sampling schedule was employed to obtain the best estimate of the effect of heat stress on serum testosterone.

Materials and Methods

Eight Angus bulls averaging about 22 months of age were used in this experiment. Following a three week adjustment period at 22 ± 1 C in temperature control chambers, bulls were randomly allotted to either a control chamber (22 ± 1 C) or a chamber with elevated ambient temperature (34 ± 1 C) and exposed continuously for 15 days. The temperatures used were similar to those employed by Meyerhoeffer *et al.* (1976) which resulted in decreased semen quality.

Cannulae were placed in the jugular veins about 15 hr before each of three sampling periods. Blood samples were taken at 30-minute intervals from 0600 hr to 1800 hr two days before heat stress (−2), and after 6 and 15 days of treatment. Respiratory rates and rectal temperatures were recorded daily throughout the treatment period.

Table 1. Serum testosterone in control and heat stressed bulls[a].

	Day of treatment		
	−2	6	15
Concentration (ng/ml)			
Control	4.2± .4[c]	3.6± .4	4.2± .7
Heat stressed	4.9± .7	4.0± .4	3.6± .3
Increases[b]/12 hr			
Control	2.0± .4	1.8± .2	2.0± .4
Heat stressed	2.0± .4	2.0± .0	1.8± .2
Maximum concentration of increases			
Control	9.2± .6	8.7± .7	9.5± 1.4
Heat stressed	10.3± .5	8.5± .6	9.0± 1.8
Area under plotted testosterone curve (units/12 hr)			
Control	613 ± 66	532 ±61	614 ±100
Heat stressed	766 ±110	588 ±64	536 ± 50

[a]Four bulls per treatment.
[b]Increases in testosterone greater than 1 SD above the $\bar{X}$.
[c]$\bar{X} \pm$ SE.

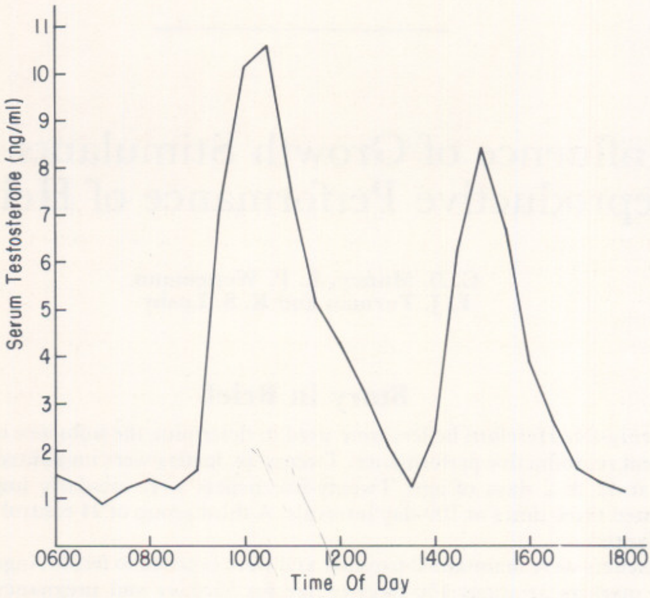


Figure 1. Serum testosterone in control bull 7609 (from 0600 hours to 1800 hours) on day 6 of treatment.

Blood serum testosterone concentrations were quantified by a specific radioimmunoassay that had been previously validated in our laboratory.

Results and Discussion

Average blood serum testosterone was similar for heat stressed and control bulls throughout the treatment period (3.76 ± .26 and 3.86 ± .40 ng/ml, respectively). Endocrine profiles for bulls on both treatments were similar over each 12-hr bleeding period. Figure 1 illustrates the variation in serum testosterone that occurred in a typical bull during a 12-hr sampling period. Both the frequency and magnitude of episodic releases of testosterone were not different between heat stressed and control bulls (Table 1).

Respiratory rates for heat stressed bulls were significantly greater than those for control bulls by day 6 of treatment and averaged 55.2 ± 2.1 and 44.6 ± 1.5 breath/minute, respectively, on day 15. Likewise, rectal temperatures were significantly increased during the experimental period and averaged 38.9 ± .1 C for heat stress compared to 38.6 ± .1 C for control bulls.

The results of this experiment indicate that exposure of bulls to elevated ambient temperature for 15 days does not appear to influence blood serum concentrations of testosterone. The absence of an effect of heat stress on serum testosterone concentrations suggests that either heat stress does not alter testicular androgen biosynthesis or adjustments in extragonadal metabolism or disposition of androgens occur so blood concentrations do not reflect testicular androgen synthesis.

Literature Cited

Meyerhoeffer, D. C., R. P. Wettemann, M. E. Wells and E. J. Turman. 1976. J. Anim. Sci. 43:331.

Influence of Growth Stimulants on Reproductive Performance of Heifers

C. D. Muncy, R. P. Wettemann
E. J. Turman and K. S. Lusby

Story in Brief

Seventy-five Hereford heifers were used to determine the influence of zeranol on subsequent reproductive performance. Twenty-six heifers were implanted with 36 mg zeranol at 42 ± 2 days of age. Twenty-five heifers were similarly implanted and reimplanted three times at 100-day intervals. A third group of 24 control heifers were not implanted.

All heifers were maintained together and were exposed to fertile Angus bulls with chinball markers at about 450 days of age for 55 days and pregnancy rates were determined by rectal palpation between 70 and 120 days after breeding. Body weights were similar for all treatments at the start of the breeding period.

Percentage of animals exhibiting estrus was not influenced by treatment, however, pregnancy rates were greater ($P<.01$) for control and single implanted heifers compared to multiple implanted heifers. Forty-six percent of the control heifers and 50 percent of the single implanted heifers were pregnant after a 55-day breeding period compared to only 4 percent of the multiple implanted heifers.

This study indicates that multiple implantation with zeranol until 100 days before the start of the breeding season has a detrimental effect on pregancy rate in heifers, whereas, a single implant prior to two months of age does not influence pregancy rate.

Introduction

Zeranol is a synthetic estrogenic compound produced by deep tank fermentation of corn grain followed by a chemical synthesis process. When implanted, this exogenous source of estrogen causes increased gain and feed efficiency and may alter normal reproductive endocrine function.

Most growth stimulants are effective in heifers as well as steers. The decision as to whether a heifer will be maintained in the breeding herd is often not made until weaning or even until a year of age. Thus, some heifers that are implanted at an early age may be added to a breeding herd at some time in the future. There is limited information on reproductive functions of heifers that have been implanted with anabolic estrogens prior to one year of age.

The objective of this experiment was to determine the influence of limited and multiple implantation with zeranol on reproductive performance of heifers.

Materials and Methods

Seventy-five Hereford heifers were blocked by age and randomly assigned at 42 ± 2 days of age and 139 ± 7 lb body weight to treatments: control (no implant), single implant (36 mg zeranol at 42 days) and multiple implant (36 mg zeranol four times at 100-day intervals starting at 42 days).

Animals were born in the spring of 1977 and maintained on native range. The winter supplementation consisted of 5 lb of 20 percent natural protein range cubes daily. Snow covered the ground for 47 days during the winter and *ad libitum* grass hay was offered in addition to range cubes on those days. During the spring of 1978, heifers were supplemented with 5 lb of ground corn per day to increase gain after the severe winter in order to achieve adequate breeding size by 15 months of age.

Heifers were exposed to fertile Angus bulls equipped with chinball markers at about 450 days of age for 55 days and were checked daily for breeding activity. Pregancy rates were determined by rectal palpation at 70 to 120 days after breeding.

Results and Discussion

Body weights (Table 1) were similar for all heifers when allotted to treatments. The body weights for the single implant heifers were significantly heavier than those of the control heifers at approximately four months of age. Weights for the multiple implant group were not significantly different from the control group at four months of age, but the multiple implant heifers were slightly heavier than the control group. Body weights were not significantly different at 8, 12 and 15 months of age, although both groups of implanted heifers tended to be heavier than the control heifers. The small differences in weights between treatments at these later periods could be attributed to the severe wintering conditions. Rate of gain was reduced for all heifers during the winter, at the age when rapid growth would be expected, thereby not allowing the effects of the implant on growth to be fully expressed.

Percentage of animals exhibiting estrus was not influenced by the treatments. However, pregnancy rates were greater for the control and limited implanted heifers ($P<.01$) than for the multiple implanted heifers (Table 1). The exogenous source of estrogenic compound (zeranol) in the multiple implant group probably inhibited ovarian function by blocking secretion of gonadotropic hormones from the pituitary gland.

These data indicate that multiple implantation with zeranol at 100-day intervals starting prior to two months of age until about 100 days before breeding has detrimental effects on pregnancy rate in heifers. However, a single implant prior to two months of age did not influence pregnancy rate.

Table 1. Characteristics of Hereford heifers implanted with a growth stimulant.

Characteristics	Treatment		
	Control	Single Implantation	Multiple Implantation
Number of heifers	24	26	25
Age at 1st implantation (da)	40	45	43
Weight at 1st implantation (lb)	140 ± 7^{a}	142 ± 6	135 ± 5
Weight at 4 months (lb)	259 ± 11^{b}	273 ± 9^{c}	264 ± 9
Weight at 8 months (lb)	346 ± 11	366 ± 11	361 ± 11
Weight at 12 months (lb)	381 ± 12	391 ± 11	398 ± 11
Age at start of breeding (da)	442 ± 4	447 ± 3	444 ± 3
Weight at start of breeding (lb)	490 ± 13	500 ± 11	523 ± 12
Weight at end of breeding (lb)	583 ± 15	595 ± 12	608 ± 13
Exhibited estrus (%)	54	65	60
Pregnancy rate (%)	46^{d}	50^{d}	4^{e}

[a]Mean ± standard error.

[b,c]Values with different superscripts differ significantly ($P<.025$).

[d,e]Values with different superscripts differ significantly ($P<.01$).

Factors Influencing the Postpartum Anestrous Interval in Range Cows

R. P. Wettemann, T. W. Beck,
E. J. Turman and J. Drew

Story in Brief

Sixty-seven anestrous Hereford cows were used to investigate treatments that may be useful to decrease the interval from parturition until estrus. The treatments used singularly or in combinations were progesterone releasing intravaginal devices (PRID), an injection of gonadotropin releasing hormone (GnRH) and 48-hr calf separation.

The interval from parturition to the onset of cyclic ovarian activity was decreased by PRID treatment ($P<.05$). The other treatments (GnRH and calf separation) did not significantly improve ovarian function. The interval from parturition to estrus was not significantly influenced by PRID or GnRH treatment. However, there was a tendency ($P=.13$) for calf separation to decrease the interval from treatment to first estrus. These data indicate that progesterone treatment and calf separation may be potential methods to decrease the postpartum anestrous interval in beef cattle.

Introduction

Many factors influence the interval from calving until the first estrus and ovulation in beef cattle. If cows are suckling calves, the anestrous interval is longer than that for nonsuckled cows. Energy intake of the cows before and after calving and intensity of suckling of the calf also influence the length of this inactive period.

The ovary is usually nonfunctional during the postpartum period. Since treatment of cows with gonadotropic hormones will initiate ovarian function, this indicates the endogenous hormones are not being secreted. The objectives of this experiment were to determine the influence of progesterone treatment, gonadotropin releasing hormone (GnRH) and short term calf separation on ovarian function and the interval from calving to first estrus in range cows.

Experimental Procedure

Hereford cows were maintained under range conditions at the Lake Carl Blackwell Range Area and supplemented so winter weight loss, including calving loss, was between 15 and 20 percent of the November weight. The cows calved between February 25 and April 21. At 35 ± 2 days after calving, 67 anestrous cows were allotted to one of the following treatments: control, insertion of a progesterone releasing intravaginal device (PRID), injection of gonadotropin releasing hormone (GnRH) or insertion of a PRID and injection with GnRH. Half of the cows on each treatment were separated from their calves for 48 hr at 45 days postpartum and the other half were not separated (Table 1). PRID's were inserted into the vagina on about day 35 postpartum and removed after 10 days. GnRH (200μg) was given intramuscularly at about 47 days postpartum.

Cows were eliminated from the study and not placed on treatment if greater than 1 ng/ml progesterone was found in one of the three blood samples collected at weekly intervals before treatment or if the cows were detected in estrus before treatment. Blood samples were obtained every other day for 40 days after treatment and progesterone concentrations were assayed as a measure of ovarian function. Bulls with chin-ball markers were used to detect estrus.

Calf separation was accomplished by trucking the cows to an isolated dry lot about one mile from their calves. The calves were maintained in an open-sided barn and were given free choice water, alfalfa hay and creep feed.

Results and Discussion

Plasma progesterone concentrations after treatment were used to determine when ovarian activity was initiated. Treatment of cows with PRID's, either alone or in combination with GnRH, decreased the interval from calving until the onset of ovarian activity ($P<.05$; Table 2). The other treatments (GnRH alone and calf separation) did not significantly influence the interval. In those cows given PRID's alone, ovarian activity had commenced by 65.2 days after calving and when cows were given PRID's and GnRH, the ovary was active by 58.9 days. However, control cows lacked ovarian activity until 70 days postpartum.

Several studies have demonstrated that plasma progesterone concentrations usually increase in postpartum anestrous cows for several days before the onset of normal cyclic ovarian activity. It is believed that this short duration of increased plasma progesterone may stimulate the hypothalamus and/or pituitary and result in gonadotropic hormone secretion. These gonadotropic hormones then stimulate the ovary to initiate ovarian function. It is possible that the progesterone released by PRID's for 10 days may mimic the increase in progesterone that usually occurs.

The interval from parturition until the first estrus was not significantly influenced by PRID or GnRH treatments (Table 3). However, there was a tendency ($P=.13$) for calf separation to decrease the anestrous interval. The first estrus occurred at 72 days after parturition in those cows that had been separated from their calves for 48 hr but it did not occur until 81.9 days in those cows that had their calves present continuously.

Table 1. Number of anestrous Hereford cows per treatment.

	Calf separation	
	None	48 hours
Control	9	8
PRID	8	8
GnRH	8	9
PRID + GnRH	8	9

PRID inserted on day 35 PP and removed on day 45. GnRH (200µg) injected on day 47 PP. Calves were separated from cows on day 45 PP for 48 hr.

Table 2. Days from calving to onset of ovarian activity in postpartum anestrous cows.

	Calves		
Treatment	Present	Separated	Average
Control	72.8	67.0	70.0
PRID	67.5	63.0	65.2
GnRH	70.0	71.3	70.7
PRID & GnRH	55.0	62.3	58.9
Average	66.5	66.0	66.2

Table 3. Days from calving to estrus in postpartum anestrous cows.

Treatment	Calves Present	Calves Separated	Average
Control	88.4	67.6	78.6
PRID	75.2	75.6	75.4
GnRH	85.0	69.4	76.8
PRID & GnRH	78.0	75.3	76.6
Average	81.9	72.0	76.9

The mechanism for the inhibition of estrus by suckling is not known. If calves are weaned, the interval from calving to estrus is usually decreased. Therefore, it appears that suckling blocks the secretion of gonadotropic hormones that stimulate the ovary. Calf separation may cause an increase in the secretion of gonadotropic hormones which stimulate growth and maturation of ovarian follicles. The follicles secrete estrogen and cause the onset of estrus.

Results of this experiment suggest that treatment of anestrous beef cows with progesterone and 48-hr calf separation may initiate ovarian function and decrease the postpartum anestrous interval.

Protein Requirements for the Young Growing Boar

R. W. Tyler, W. G. Luce, R. K. Johnson, C. V. Maxwell and L. E. Walters

Story in Brief

Five trials, involving 432 growing boars, were conducted to study the effects of six levels of crude protein on average daily gain, feed efficiency, average daily feed intake, average backfat thickness and average *longissimus* muscle area. Boars were self-fed either a 14, 16, 18, 20, 22 or 24 percent crude protein ration from approximately 48 to 120 lb (Period 1). Crude protein was reduced 2 percent as pens of boars reached an average weight of 120 lb.

In Period 1 (48-120 lb), average daily gain was highest in boars fed a 20 percent protein ration and maximum feed efficiency was observed in boars fed a 22 percent protein ration. Feeding either higher or lower protein levels resulted in a reduction in both average daily gain and feed efficiency (significant quadratic response $P<.0005$ and $P<.01$, respectively).

In Period 2 (120 to 220 lb), protein level did not significantly affect rate of gain, feed efficiency or average daily feed intake.

For the entire feeding period, maximum average daily gain and *longissimus* muscle area was observed in boars fed a 20 percent ration during Period 1 and an 18 percent protein ration during Period 2. Both gain and *longissimus* muscle area was reduced at either higher or lower protein levels (significant quadratic effect $P<.003$ and $P<.0001$, respectively). Efficiency of gain improved and backfat thickness decreased as dietary protein increased (significant linear effect, $P<.0001$ and $P<.001$, respectively).

The results of this study indicated that small improvements in average daily gain, feed efficiency, loin eye area and backfat thickness can be made. This can be done by feeding protein levels to growing boars approximately 2 percent higher than the currently recommended 18 percent protein ration during the growing period (48 to 120 lb). Follow by feeding a 16 percent protein ration during the finishing period (120 to 220 lb). It is doubtful, however, that the amount of improvement is adequate to offset the economic disadvantages of a more expensive ration.

Introduction

Information concerning the protein requirement of the growing boar is somewhat limited. Most recommendations are made assuming that boars require a higher level of protein supplementation than barrows or gilts because of the higher lean to fat ratio in growing boars. Although several studies have been conducted recently with growing boars suggesting that the protein requirement is higher than that for barrows or gilts,

Table 1. Composition of experimental rations.

	Level of protein						
	Treatments[a]						
	1		3		5		
		2		4		6	
Ingredient (%)	12% CP	14% CP	16% CP	18% CP	20% CP	22% CP	24% CP
Yellow corn	83.14	75.0	69.5	64.0	58.3	52.8	47.25
Soybean meal (44%)	8.31	16.5	22.1	27.75	33.5	39.1	44.75
Wet molasses	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	1.8	1.75	1.65	1.5	1.4	1.3	1.2
Calcium carbonate	0.7	0.7	0.7	0.7	0.75	0.75	0.75
Vitamins-T.M. mix[b]	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Aureomycin 50	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% crude protein, cal.	12.0	14.03	15.99	17.99	20.02	22.00	24.00
% calcium, cal.	0.71	0.71	0.71	0.69	0.69	0.71	0.70
% phosphorus, cal.	0.61	0.61	0.61	0.61	0.61	0.61	0.61
% lysine, cal.	0.37	0.59	0.73	0.92	1.07	1.15	1.29

[a]Two rations under each treatment indicate protein levels fed during Periods 1 and 2. The higher protein level was fed from 48 to 120 lb (Period 1) followed by a 2% reduction in protein from 120 to 220 lb (Period 2).

[b]Supplied 3,000,000 I.U. vitamin A, 3,000,000 I.U. vitamin D, 4 gm riboflavin, 20 gm pantothenic acid, 30 gm. niacin, 1,000 gm choline chloride, 15 mg vitamin B_{12}, 6,000 I.U. vitamin E, 20 gm. menadione, 0.2 gm iodine, 90 gm iron, 20 gm manganese, 10 gm copper and 90 gm zinc per ton of feed.

the results of these trials have been inconsistent and the requirement for growing boars has not been sufficiently established.

A series of trials involving a large number of boars was initiated in 1975 at Oklahoma State University and continued through 1978 to establish the crude protein levels in growing boars (48 to 220 lb) which would maximize gain, feed efficiency and muscle development.

Experimental Procedure

Five trials were conducted with a total of 432 Duroc, Hampshire and Yorkshire boars. In Trials 1, 2 and 3, 108 boars were allotted to three treatments and 54 boars were allotted to three treatments during Trials 4 and 5. During the first period of each trial (48 to 120 lb), the boars were fed either a 16, 18 or 20 percent crude protein ration (Trials 1 and 2); 14, 16, 18 percent crude protein ration (Trial 3); 18, 20 or 22 percent crude protein ration (Trial 4); or a 20, 22 or 24 percent crude protein ration (Trial 5). In the second period (120 to 220 lb), the protein level of each diet was reduced 2 percent. The composition of each ration is shown in Table 1.

The boars were allotted to treatments as they reached eight weeks of age. The allotment on any day included 27 boars with an equal number of boars from each of the three breed groups. Assignment to pens was done randomly within breed and litter. This group of boars constituted one block, consisting of three pens with an equal

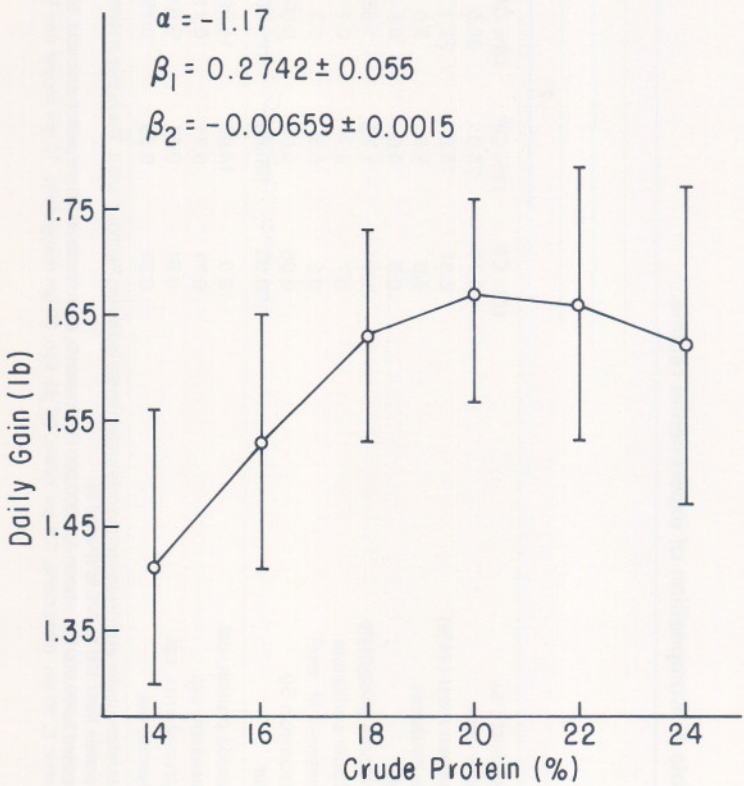


Figure 1. Average daily gain - Period 1.

number of boars of the three breed groups, for each individual trial. Trial 1, 2 and 3 contained four blocks each while Trials 4 and 5 contained two blocks.

The feeding floor was an open-front concrete finishing floor equipped with a self-feeder and automatic waterer. After assignment of nine boars per pen, the boars were given a one-week adjustment period after which on-test weights were recorded.

Protein levels in the ration were reduced for each pen individually as the boars in the pen averaged 120 lb, and boars were individually removed from test weekly as they reached 220 lb. Ultrasonic estimates of backfat thickness and *longissimus* muscle area were obtained by the use of an Ithaco Scanogram Model 721 instrument, and the measurements were adjusted to a 220 lb equivalent. Adjustments used were ± .015 sq in for *longissimus* muscle area for each lb below or above 220 lb.

To determine the average change in growth of these boars as the level of crude protein increased in two percent increments (14 to 24 percent), a regression analysis was performed on the combined trial data.

Results and Discussion

Period 1

During Period 1 average daily gain increased with increasing dietary protein levels to 20 percent of the diet followed by a decline in gain with increasing dietary protein (Figure 1, significant quadratic effect $P<.0005$). It should be noted that the improve-

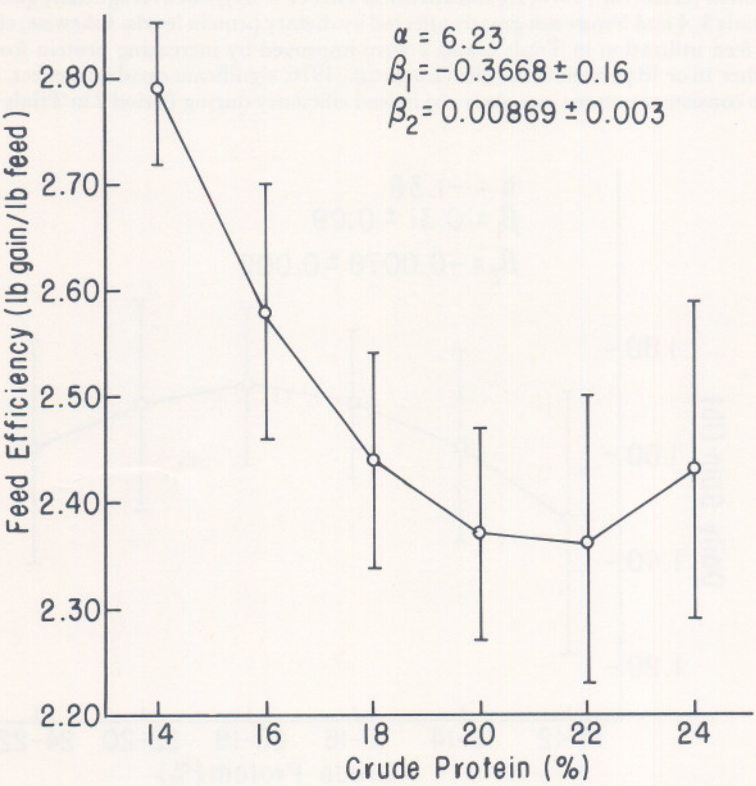


Figure 2. Feed efficiency - Period 1.

ment in gain attained by feeding protein levels above 18 percent was small (.04 lb per day increase from 18 to 20 percent protein). This data indicates that gain in young boars (48 to 120 lb) was maximized at protein levels from 18 to 20 percent. Since little improvement is noted above 18 percent protein, there appears to be little justification for feeding levels above 18 percent protein.

Efficiency of feed utilization in Period 1 reached a maximum at protein levels from 20 to 22 percent before beginning to decline at 24 percent protein (Figure 2, significant quadratic effect, $P<.01$). The amount of improvement in feed efficiency, however, at protein levels above 18 percent crude protein was small (0.17 lb feed/lb gain in going from 18 to 20 percent protein). From a practical standpoint the standard recommendation of an 18 percent crude protein corn-soybean meal ration for growing boars is very close to protein levels which maximize feed efficiency.

Although there appeared to be a slight reduction in feed intake at both the high and low protein levels, these differences were not significant in any of the individual trials or in the analysis of the combined trials.

Period 2

Protein level in the analysis of the combined trials did not significantly affect rate of gain, feed efficiency or average daily feed intake in boars from 120 to 220 lb. However, in analysis of Trials 1 and 2 average daily gain increased with increasing protein (Luce *et al.*, 1976, significant linear effect $P<.01$), but average daily gain during Trials 3, 4 and 5 were not greatly affected by dietary protein levels. Likewise, efficiency of feed utilization in Trials 1 and 2 were improved by increasing protein from 14 to either 16 or 18 percent of the diet (Luce *et al.*, 1976, significant quadratic effect, $P<.01$). No consistent pattern was observed in feed efficiency during Period 2 in Trials 3, 4 and 5.

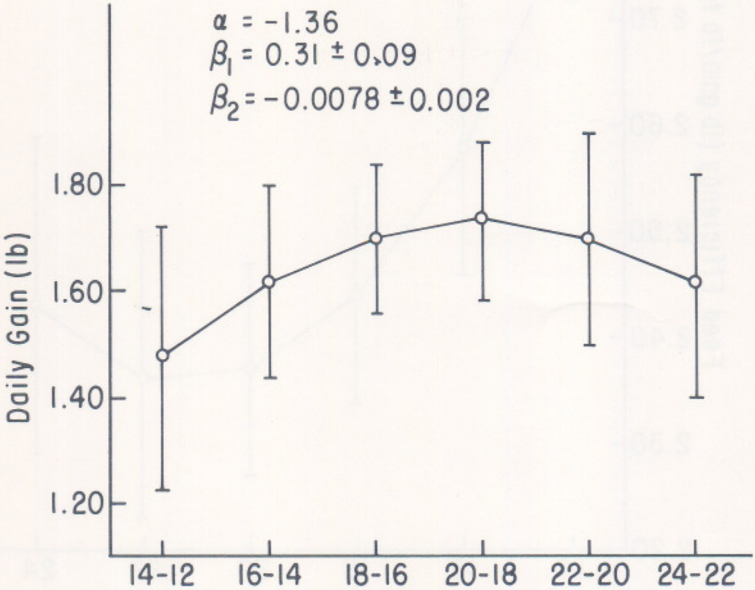


Figure 3. Average daily gain - total trial period.

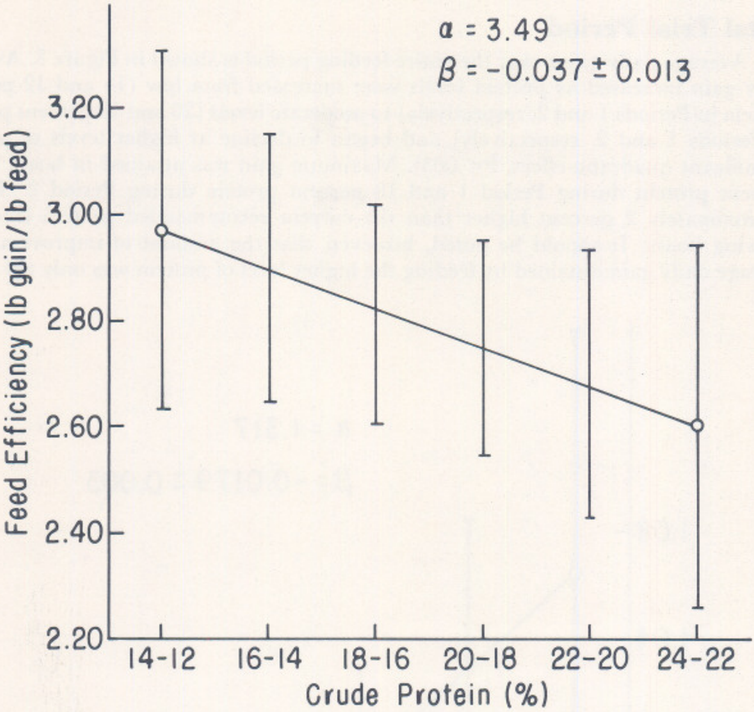


Figure 4. Feed efficiency - total trial period.

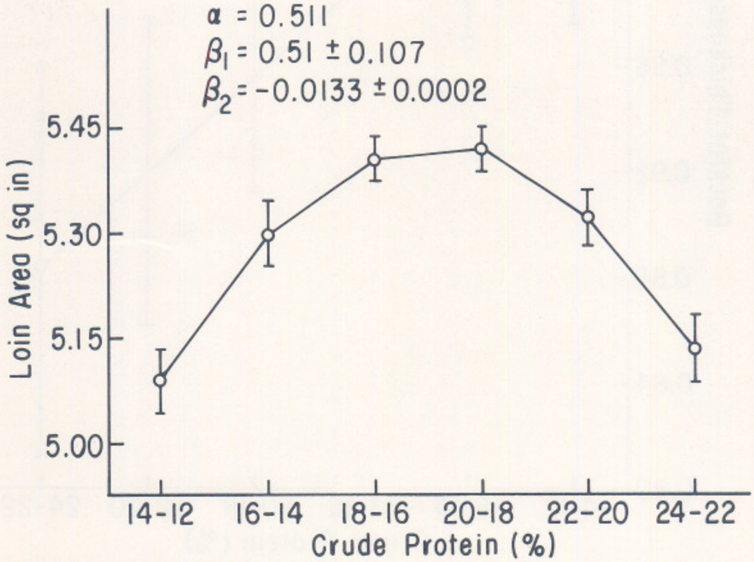


Figure 5. Longissimus dorsi muscle area - adjusted to 220 lb.

Total Trial Period

Average daily gains over the entire feeding period is shown in Figure 3. Average daily gain increased as protein levels were increased from low (14 and 12 percent protein in Periods 1 and 2, respectively) to moderate levels (20 and 18 percent protein in Periods 1 and 2, respectively) and began to decline at higher levels of protein (significant quadratic effect, $P<.003$). Maximum gain was attained in boars fed 20 percent protein during Period 1 and 18 percent protein during Period 2. This is approximately 2 percent higher than the current recommended protein levels for growing boars. It should be noted, however, that the amount of improvement in average daily gain obtained by feeding the higher level of protein was only .04 lb per day.

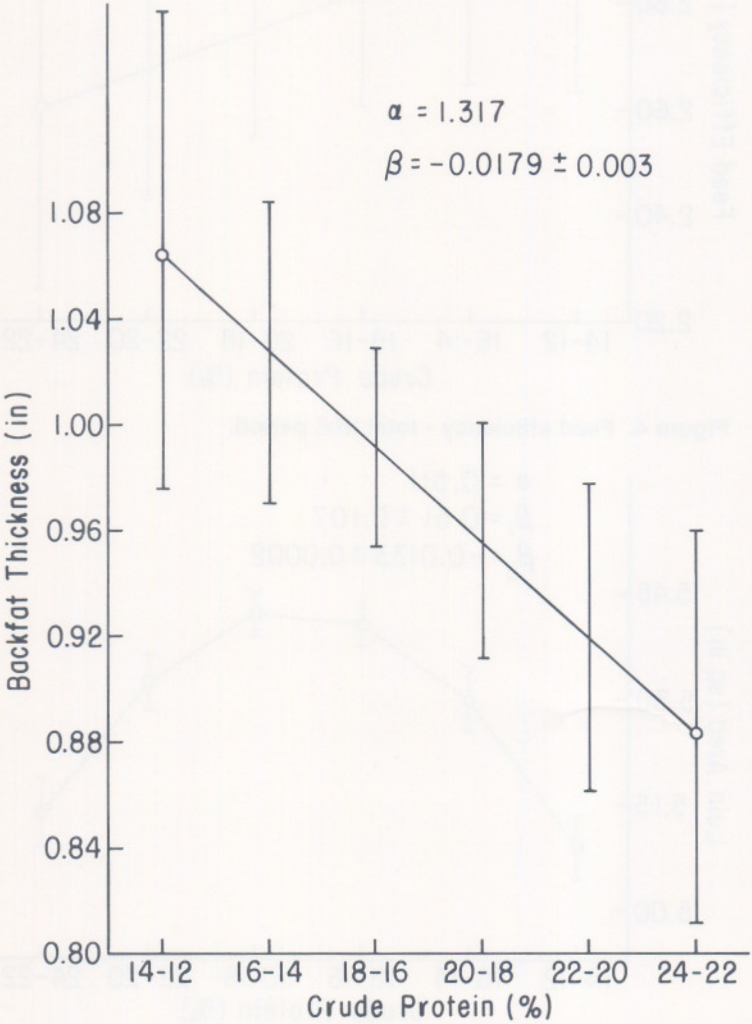


Figure 6. Backfat thickness - adjusted to 220 lb.

Efficiency of feed utilization improved in every trial (Trials 1, 2, 3, 4 and 5) as percentage of dietary protein increased, producing a linear ($P<.0001$) response to increasing protein when these trials were combined (Figure 4). This amount to a reduction in feed efficiency of approximately 0.15 lb of feed per lb of gain for every 4 percent reduction in dietary protein level. These findings are not in total agreement with Luce *et al.*, (1976) who reported a quadratic ($P<.05$) response or Spear *et al.*, (1957), and Bereskin *et al.*, (1975), who stated protein levels from 15 percent to 24 percent and 14 percent to 20 percent, respectively, have little effect on feed efficiency. However, Hale (1967), reported reduced feed required per unit weight gain as protein was increased.

Average daily feed intake tended to increase as growing boars (approximately 48 to 220 lb) were fed increasing levels of crude protein, from 14 percent to 20 percent and decreased as protein level increased to 22 and 24 percent. This trend was not significant (quadratic effect, $P<.23$) but the tendency for an increasing average daily feed intake through the 20 percent protein level is in agreement with results published by other workers (Bereskin *et al.*, 1975 and Luce *et al.*, 1976).

Longissimus muscle area (Figure 5) increased as protein was increased from low (14 and 12 percent protein during periods 1 and 2, respectively) to moderate protein levels (20 and 18 percent protein during Period 1 and 2, respectively) and decreased in pigs fed higher levels of protein (significant quadratic effect ($P<.0001$). It should be noted that protein levels which maximize gain in the total trial period and gain and efficiency in Period 1 correspond very closely with protein levels which produced maximum *longissimus* muscle area.

Backfat thickness (Figure 6) decreased as level of protein increased (significant linear effect, $P<.001$). This response although constant is not very large and a change in protein level of 2 percent only produces a reduction in backfat thickness of approximately 0.04 inches of backfat. Although backfat would probably be decreased in boars fed protein levels higher than are currently recommended, this advantage would probably not offset the disadvantages of a decreased rate of gain or a reduction in *longissimus* muscle area.

Literature Cited

Bereskin, B. R., 1975, J. Anim. Sci. 40:53.

Hale, O. M., 1967, J. Anim. Sci. 26:341.

Luce, W. G., 1976, J. Anim. Sci. 42:1207.

Spear, V. C., 1957, J. Anim. Sci. 16:607.

Whey-Grown Yeast as a Protein Source for Baby Pigs

Y. J. Ajeani, C. V. Maxwell, F. N. Owens, D. Holbert, K. B. Poling and J. S. Schooley

Story in Brief

The nutritive value of whey-grown yeast for baby pigs was examined. In experiment one, 25 pigs were randomly assigned to four diets containing 0.9 percent total lysine with 0, 25, 50 and 75 percent lysine furnished by whey-yeast and the rest from soybean meal, and one ration at 0.8 percent lysine with all supplemental lysine from soybean meal. Including whey-yeast in the diet improved gains a mean of 18 percent. The highest level of yeast fed improved feed efficiency by 35 percent and protein efficiency ratio by 53 percent.

In Trial 2, 25 pigs were allotted on a basis of litter to four diets containing 0.9 percent lysine with 0, 50, 75 and 83 percent lysine furnished by whey-yeast and one ration at 0.8 percent lysine with all supplemental lysine from soybean meal. At 0.9 percent dietary lysine, the corn-whey-yeast diet improved rates of gain, feed utilization and protein efficiency ratio by 28, 23 and 51 percent over the corn-soybean meal diet.

In Trial 3, 24 pigs were assigned to four diets containing 0.9 or 1.0 percent lysine from yeast or soybean meal. At both 0.9 and 1.0 percent levels of dietary lysine, whey-yeast produced higher rates of gain (34 and 24 percent, respectively) and better feed and protein utilization than soybean meal.

It was concluded that whey-grown *Kluyveromyces fragilis* yeast, at levels up to 12 percent of the diet, has no adverse effects on baby pigs and that whey-yeast protein was superior to soybean meal protein for growth rate and feed efficiency of baby pigs by means of 30 and 33 percent.

Introduction

Disposal of whey, a byproduct of the cheese industry, is a major industrial problem. Work to-date at OSU has shown promise in the use of yeast to reduce the total solids and biological oxygen demand of the waste whey. In the process, a 65 percent protein whey-yeast byproduct is produced in large amounts. Studies indicate that yeast proteins are apparently toxicologically safe and economical supplements for swine. However, variations in strains of yeast, the nature of the substrate used in producing yeast and differences in preparation and handling procedures require further research.

In this study, the effect of whey-grown yeast on feed consumption, growth, efficiency of feed and protein utilization in the young pig was investigated.

Materials and Methods

Three feeding experiments were conducted with a total of 74 Yorkshire male baby pigs to evaluate whey-grown *Kluyveromyces fragilis* yeast (Table 1) as a dietary protein source. The three experiments differed in design and treatment combinations but were similar in diet preparation and animal management practices. Corn and the whey-yeast used were ground through 1/8 inch and 1/16 inch screens.

Individual feeding crates equipped with self-feeders and automatic waterers were used to house pigs. Feed and water were supplied free choice. Quantity of feed offered, feed wastage and feed refusal were recorded.

Table 1. Analysis of whey-grown *kluyveromyces fragilis* yeast as compared to soybean meal.

Item	% of as-fed product	
	K. fragilis	*Soybean meal**
Moisture	8.59	11.0
Calcium	.27	.32
Phosphorus	.40	.67
Protein (N x 6.25)	63.07-67.04	45.8
Amino acid (g/100g C.P.)		
Alanine	3.99	-
Arginine	1.89	3.20
Aspartic acid	8.18	-
Cystine	3.33	.67
Glutamic acid	11.21	-
Glycine	1.90	-
Histidine	1.23	1.10
Isoleucine	3.36	2.50
Leucine	8.24	3.40
Lysine	6.92	2.90
Methionine	1.49	.60
Phenyalanine	2.89	2.20
Proline	3.62	-
Serine	3.63	-
Threonine	3.88	1.70
Tryptophan	-	.60
Tryosine	2.53	1.40
Valine	3.53	2.40

*Figures obtained from N.R.C. (1973).
-Value not determined.

In experiment one, 25 pigs averaging 3.5 weeks old and 13.3 lb in initial weight were randomly assigned to five treatments. Treatments comprised five corn-soybean meal diets formulated on the basis of total dietary lysine (Table 2). Whey-yeast furnished 0, 0, 25, 50 and 75 percent of the total lysine in diets 1, 2, 3, 4 and 5, respectively.

In the second experiment, 25 pigs (five from each of five litters) averaging 3.5 weeks old and 13.5 lb in initial body weight were randomly allotted to five diets on the basis of litter. The treatments (Table 3) comprised diets 1 and 2 used in experiment one and diets 3, 4 and 5 in which whey-yeast lysine formed 50, 75 and 83 percent of total lysine. All the soybean meal was replaced by whey-yeast in diet 5.

In experiment three, 24 pigs averaging 3.5 weeks of age and 13.0 lb in initial body weight were randomly allotted to four dietary treatments (Table 4) with two sources (soybean meal and whey-yeast) and two levels of protein.

Results and Discussion

Problems encountered with early weaning of baby pigs include digestive disorders associated with diarrhea and/or depressed appetite and slow adaptation to dry feed. These problems are more common with some diets than others. The data obtained at the end of the first week of experiments one and two were analyzed to determine the effect, if any, of whey-yeast on the ability of pigs to adapt to the feed regime.

During the first week of experiment one, no significantly different response of pigs to the treatments were observed with respect to average daily gain, average daily feed

Table 2. Calculated composition of diets used in experiment 1.

	% Composition (as-fed)				
	Diet No.				
Ingredients	1	2	3	4	5
Corn	73.61	70.10	74.45	78.79	83.10
Soybean meal	23.12	26.69	18.66	10.62	2.62
Whey-grown yeast	-	-	3.67	7.34	11.01
DL-methionine (98% pure)	0.22	0.20	0.15	0.10	0.05
Dicalcium phosphate	0.27	0.23	0.31	0.40	0.49
Calcium carbonate	1.68	1.68	1.66	1.65	1.63
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05	0.05
Calculated analysis					
Crude protein (N x 6.25)	16.65	17.91	17.08	16.23	15.41
Calcium	0.80	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59	0.59
Lysine, total	0.80	0.90	0.90	0.90	0.90
Methionine + cystine	0.74	0.74	0.76	0.76	0.76
Tryptophan*	0.20	0.22	0.18*	0.13*	0.09*
Yeast lysine (% of total)	-	-	25.00	50.00	75.00

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan was expected to come from whey-yeast.

Table 3. Calculated composition of diets used in experiment 2.

	% Composition (as-fed)				
	Diet No.				
Ingredients	1	2	3	4	5
Corn	73.61	70.10	78.79	83.10	84.55
Soybean meal	23.12	26.69	10.62	2.62	-
Whey-grown yeast	-	-	7.34	11.01	12.20
DL-methionine (98% pure)	0.22	0.20	0.10	0.05	-
Dicalcium phosphate	0.27	0.23	0.40	0.49	0.52
Calcium carbonate	1.68	1.68	1.65	1.63	1.63
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05	0.05
Calculated analysis					
Crude protein (N x 6.25)	16.65	17.91	16.23	15.41	15.13
Calcium	0.80	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59	0.59
Lysine, total	0.80	0.90	0.90	0.90	0.90
Methionine + cystine	0.74	0.74	0.76	0.76	0.68
Tryptophan	0.20	0.22	0.13*	0.09*	0.08*
Yeast lysine (% of total)	-	-	50.00	75.00	83.00

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan expected from whey-yeast.

Table 4. Calculated composition of diets used in experiment 3.

Ingredients	% Composition (as-fed)			
	Diet No.			
	1	2	3	4
Corn	70.04	85.80	69.90	85.66
Soybean meal	26.69	-	26.70	-
Whey-grown yeast	-	10.85	-	10.86
DL-methionine (98% pure)	0.27	0.10	0.27	0.10
Lysine hydroxychloride (78.5% lysine)	-	-	0.13	0.13
Dicalcium phosphate	0.23	0.51	0.23	0.51
Calcium carbonate	1.67	1.64	1.67	1.64
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05
Calculated analysis				
Crude protein (N x 6.25)	17.91	14.39	17.90	14.39
Calcium	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59
Lysine, total	0.90	0.90	1.00	1.00
Methionine + cystine	0.73	0.73	0.73	0.73
Tryptophan	0.22	0.08*	0.22	0.08*

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan comes from whey-yeast.

consumption and average gain: feed (feed efficiency) ratio (Table 5). Although the level of protein in the diet decreased as graded levels of whey-yeast lysine were substituted for 25, 50 and 75 percent of total lysine (Table 5), average daily protein intake values were not affected. Since carryover effects of previous nutritional management and change of housing environment were common to all pigs, these results indicate that whey-yeast has no adverse or positive effects on adaptation of baby pigs to the diet.

Over the entire five-week period of the experiment one (Table 6), the inclusion of up to 11 percent whey-yeast in the diet did not reduce feed consumption. Average daily gain tended to be improved (23, 4 and 30 percent when 25, 50 and 75 percent of the 0.9 percent dietary lysine was supplied by whey-yeast). Feed efficiency and protein efficiency ratios were higher when whey-yeast was added to the diet at any level.

At the highest level of whey-yeast fed, improvements of 35 and 53 percent in feed efficiency and protein efficiency ratio were obtained. Advantage of whey-yeast over soybean meal as a source of protein when fed to baby pigs with corn as an energy source was implicated in this experiment.

During the first week of experiment two, no treatment differences existed with respect to rate of gain, feed consumption, efficiency of feed utilization, protein intake or protein efficiency ratio (Table 7). Over the entire five-week period of experiment two (Table 8), the inclusion of whey-yeast in the diet improved rate of gain, feed efficiency and protein efficiency ratio when 0.9 percent lysine was fed.

Best performance was obtained when all the soybean meal lysine was replaced with whey-yeast lysine. The corn-whey yeast diet (diet 5) produced 28, 23 and 51 percent greater rates of gain, feed efficiency and protein efficiency ratio, respectively, than the corn-soybean meal diet. The results of this experiment corroborate those of experiment one. Overall pig performance improved with increasing dietary levels of whey-yeast lysine.

Table 5. Performance of pigs during the first week of experiment 1.

Variable	Diet Number				
	1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	25	50	75
No. of pigs	5	5	5	5	5
Avg initial wt, lb	13.9	14.0	12.5	13.4	12.8
Avg daily feed, lb*	0.42	0.61	0.53	0.64	0.58
Avg daily gain, lb	0.09	0.06	0.19	0.11	0.21
Avg feed efficiency gain/feed	−0.04	−0.04	0.32	0.08	0.32
Avg daily protein, lb	0.08	0.13	0.11	0.12	0.11
Avg protein efficiency, gain/protein	−0.23	−0.19	1.60	0.41	1.69

*Average daily feed dry matter intake.

Table 6. Performance of pigs over the entire 5-week period of experiment 1.

Variable	Diet Number				
	1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	25	50	75
No. of pigs	5	5	5	5	4
Avg initial wt, lb	13.9	14.0	12.5	13.4	12.8
Avg daily feed, lb*	1.47	1.53	1.59	1.43	1.49
Avg daily gain, lb	0.47^{a}	0.64^{ab}	0.79^{b}	0.67^{ab}	0.84^{b}
Avg gain/feed	0.31^{a}	0.41^{ab}	0.50^{bc}	0.46^{bc}	0.56^{c}
Avg daily protein, lb	0.28	0.33	0.32	0.28	0.28
Avg gain/protein	1.64^{a}	1.93^{ab}	2.48^{bc}	2.40^{bc}	2.96^{c}

*Average daily feed dry matter intake.
^{abc}Means in a row with different superscripts differ significantly ($P<.05$).

Table 7. Performance of pigs during the first week of experiment 2.

Variable	Diet number				
	1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	50	75	83
No. of pigs	5	5	5	5	5
Avg initial wt, lb	11.4	13.7	12.6	15.2	15.2
Avg daily feed, lb*	0.83	0.89	0.99	1.01	0.96
Avg daily gain, lb	0.00	1.11	0.10	0.07	0.11
Avg gain/feed	−0.04	0.09	0.11	0.06	0.12
Avg daily protein, lb	0.16	0.19	0.20	0.19	0.17
Avg gain/protein	−0.22	0.42	0.58	0.32	0.65

*Average daily feed dry matter intake.

Table 8. Performance of pigs over the entire 5-week period of experiment 2.

Variable	Diet number 1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	50	75	83
No. of pigs	5	5	5	5	5
Avg initial wt, lb	11.4	13.7	12.6	15.2	15.2
Avg daily feed, lb*	1.24	1.29	1.36	1.34	1.34
Avg daily gain, lb	0.41[a]	0.51[ab]	0.62[bc]	0.60[bc]	0.65[c]
Avg gain/feed	0.33[a]	0.39[ab]	0.46[bc]	0.45[bc]	0.49[c]
Avg daily protein, lb	0.23	0.28	0.27	0.25	0.24
Avg gain/protein	1.74[a]	1.83[a]	2.32[b]	2.35[b]	2.75[b]

*Average daily feed dry matter intake.
[abc]Means in a row with different superscripts differ significantly (P<.05).

Table 9. Performance of pigs over the 5-week period of experiment 3.

Variable	Diet number 1	2	3	4
Diet composition*	CSBM	CWY	CSBM	CWY
Total lysine, %	0.90	0.90	1.00	1.00
No. of pigs	6	5	5	5
Avg daily feed, lb**	1.41	1.36	1.30	1.43
Avg daily gain, lb	0.53	0.71	0.62	0.77
Avg gain/feed	0.37[a]	0.52[b]	0.47[ab]	0.64[c]
Avg daily protein	0.28[a]	0.22[b]	0.26[a]	0.21[b]
Avg gain/protein	1.92[a]	3.15[b]	2.35[a]	3.72[b]

*CSBM-corn/soybean meal diet.
**CWY-corn/whey-yeast diet.
[abc]Means in a row with different superscripts differ significantly (P<.05).

The results of experiment three are presented in Table 9. At both .90 and 1.00 percent dietary lysine, the source of protein did not affect feed consumption. Corn-whey-yeast diets produced faster growth rates at both levels of dietary lysine than did corn-soybean meal diets. Within each level of dietary lysine, corn-whey-yeast diets produced greater feed efficiency (P<.05) and protein efficiency ratio (P<.05) than corn-soybean meal diets.

The level of dietary lysine had no effect on pig performance (P<.05) when pigs were fed corn-soybean meal diets but when fed corn-whey-yeast diets, pigs showed greater feed efficiency and protein efficiency ratio at 1.00 percent than at 0.9 percent dietary lysine.

If lysine and protein were the limiting factors of performance, then the pigs fed 1.0 percent lysine in the corn-soybean meal diet at 17.9 percent protein should have performed better than those fed .90 percent lysine in the corn-whey-yeast diet at 14.39 percent protein. Since pigs fed the higher level of lysine and protein did not perform as well, this suggests that protein was not a limiting factor and that lysine and/or other dietary indispensible amino acids may have been more readily available from whey-yeast than from soybean meal.

As long as the baby pig's requirement for dietary lysine is met, the level of protein in the diet is a function of the source of protein and can be as low as 14 percent for whey-yeast based cereal diets without depressing gain.

In this experiment, pigs fed corn-whey-yeast at 14.4 percent protein and .9 percent dietary lysine had 35, 40 and 65 percent greater rate of gain, gain: feed ratio and gain: protein ratio, respectively, than those pigs fed the corn-soybean meal diet at 0.9 percent lysine and 17.9 percent crude protein. At 1.0 percent lysine (14.3 percent protein), the corn-whey-yeast diet produced 25, 35 and 59 percent greater average daily gain, feed efficiency and protein efficiency ratio over the 17.9 percent protein corn-soybean meal diet.

The results of this study indicate that whey-yeast protein is consistently superior to soybean meal protein for baby pigs. The reasons for this are unclear; however, whey-yeast protein contains higher levels of most indispensible amino acids than soybean meal protein. The possibility of whey-yeast lysine being more readily available to the pig than soybean meal lysine is suggested in this study.

Literature Cited

N.R.C. 1973. Nutrient Requirements of Domestic Animals, No. 2. Nutrient requirements of swine. National Academy of Science - National Research Council, Washington, DC.

Influence of Protein Intake, Energy Intake and Stage of Gestation on Protein Status of the Gestating Gilt

G. M. Willis and C. V. Maxwell

Story in Brief

Thirty-six crossbred gilts were fed three levels of protein (8, 14 and 20 percent protein diets) and two levels of energy (approximately 6200 kcal DE/day and 6200 kcal DE/day + 20 percent) throughout gestation. Five-day nitrogen balance studies were conducted at early (0-30 days), mid (30-60 days) and late (60-90 days) gestation. At slaughter (90 days gestation), reproductive tracts were evaluated for reproduction performance and samples of the reproductive tract and semimembranosus muscle were analyzed for crude protein.

The results of this experiment suggest that an 8 percent protein ration during gestation is just as effective as the higher levels of crude protein intake for litter size or storage of protein in the reproductive tissue. However, storage of protein in muscle tissue increased as protein level was increased to levels from 14 to 20 percent crude protein. No advantage for the higher energy diets for these traits was noted.

Introduction

Several recent studies have been unable to establish a relationship between protein or energy intake on subsequent litter size or pig weight at birth. This suggests that the gestating gilt or sow is able to utilize tissue stores for the normal development of the fetus to parturition even under conditions of suboptimum energy and/or protein nutrition. However, more recent studies have shown that the depletion of stores during gestation does have an adverse effect on lactation performance as measured by litter size and litter weight at weaning.

The amount of tissue stores needed to optimize subsequent lactation performance has not been adequately determined. The fate of this stored muscle nitrogen at parturition and its role is subsequent lactation and rebreeding performance is an unanswered question.

The objectives of this study were to examine nitrogen retention in the pregnant gilt as affected by protein intake, energy intake and stage of gestation. Concurrent evaluation of reproductive performance, growth rate and tissue protein content were conducted.

Materials and Methods

Thirty-six crossbred (two and three breed crosses of Hampshire, Yorkshire and Duroc) gilts were fed three levels of protein (8, 14 or 20 percent crude protein) and two levels of energy (moderate (M) and high (H)). The M20 percent crude protein corn-soybean meal diet was extended with corn starch to give the M8 percent and M14 percent crude protein rations. The moderate energy rations were further extended with corn starch to increase the digestible energy content of the moderate energy rations by 20 percent to yield the high energy rations (Table 1). Thus, amino acid rations across protein levels were maintained.

Gilts were randomly assigned to one of four dirt lots at approximately 270 days of age. Gilts were fed once daily in individual feeding stalls and had access to drinking water and shelter. Gilts were observed daily for signs of estrus by introducing a teaser boar into the pens and were bred on the second estrus after initiation of the trial. After breeding, gilts were changed from 5.0 lb of a 16 percent crude protein diet to 4.0 lb (moderate energy rations) or 4.75 lb (high energy rations) of the experimental diets. On days 25, 55 and 85 of gestation, urine and feces were collected for four days.

Gilts were slaughtered on day 90 of gestation. Reproductive tracts were recovered as quickly as possible after slaughter and uniformly trimmed. The reproductive tracts were weighed and evaluated immediately for reproductive status. Corpora lutea counts were recorded for each ovary and each uterine horn was dissected from the cervical end to obtain embryo numbers.

All solid tissues including the uterus, ovaries, placenta, and fetuses were ground twice in a Hobard Model 4332 grinder and a ground sample was quickly frozen for subsequent nitrogen analysis. Volumes were recorded for freely draining uterine fluids

Table 1. Calculated composition of experimental diets.

Item	M 8%	H 8%	M 14%	H 14%	M 20%	H 20%
Corn (9%)[a]	24.75	20.81	44.76	37.70	64.77	54.64
Soybean meal (44%)[a]	12.31	10.35	22.25	18.74	32.20	27.17
Corn starch (0.6%)[a]	59.24	65.73	29.62	40.72	- - - - -	15.63
Dicalcium phosphate	1.94	1.63	1.33	1.12	0.71	0.60
Calcium carbonate	0.76	0.64	1.04	0.88	1.32	1.11
Vitamin T.M. premix[b]	0.50	0.42	0.50	0.42	0.50	0.42
Salt	0.50	0.42	0.50	0.42	0.50	0.42

[a]Estimated percent protein given in parentheses.

[b]Vitamin-trace mineral premix supplied 2004 IU Vitamin A, 150 IU Vitamin D_3, 5 IU Vitamin E, 2.0 mg riboflavin, 10 mg d-pantothenic acid, 15 mg niacin, 400 mg choline chloride, .0075 mg Vitamin B_{12}, 1.0 mg menadione sodium bisulfite per lb of diet and 22 PPM Mn, 100 PPM Zn, .22 PPM I,99 PPM Fe, and 11 PPM Cu. (High energy rations supply 84% of these values).

and a sample was frozen for nitrogen analysis. The liver and the semimembranosus muscle of each left ham was removed as soon after slaughter as possible and weighed. The muscle was quickly ground and samples frozen for subsequent nitrogen analysis.

Carcass weights were obtained and the right side of the carcass was subject to a physical separation of fat, lean and bone.

Body weight, growth data and nitrogen balance data were analyzed as a 3 x 2 x 3 factorial arrangement of treatments in a split plot design. Each animal was a main plot with main plot treatments being level of protein in the diet (8, 14 and 20 percent) and dietary energy level (moderate and high). The subplot treatment corresponded to stages of gestation (30,60 and 90 days). Remaining data variables measured in just one period were analyzed as a 3 x 2 factorial arrangement of treatments in a completely randomized design. The two treatment factors were protein level in the diet (8, 14 and 20 percent) and energy level in the diet (moderate and high).

Results and Discussion

Growth

The initial weight and slaughter weight of gilts are presented in Table 2. There were no significant trends in slaughter weight of gilts due to protein level or energy level of the diet. The mean slaughter weights (lb) were 376, 390.5 and 387.6 for the 8, 14 and 20 percent protein diets and 382.6 and 386.3 for the M (moderate) and H (high) energy levels, respectively.

Reproductive performance

Numbers of corpora lutea were 13.3, 13.9 and 12.6 for protein levels of 8 percent, 14 percent and 20 percent respectively (Table 3). For the M and H energy levels, the mean numbers of corpora lutea were 13.4 and 13.2, respectively. None of these values was significantly affected by level of protein intake or level of energy intake.

The mean embryo numbers were 10.9, 9.8 and 10.4 for the 8 percent, 14 percent and 20 percent crude protein diets, respectively. The embryo numbers for both the M and H energy diets were 10.4. There was no significant trends in these values caused by level of protein intake or energy intake.

Nitrogen balance

As protein level increased, nitrogen retention increased linearly ($P<.005$) with mean values of 10.3, 16.6 and 22.6 g/day for protein levels 8, 14 and 20 percent

Table 2. Body weight and growth data of gilts.[a]

	Protein level			Energy level	
Item	8%	14%	20%	M	H
No. of gilts	12	11	10	17	16
Initial wt, lb	293.5	292.1	293.3	297.0	288.9
Slaughter wt, lb	376.0	390.5	387.6	382.6	386.3

[a]Means

Table 3. Reproductive performance of gilts.[a]

	Protein level			Energy level	
Item	8%	14%	20%	M	H
No. of corpora lutea	13.3	13.9	12.6	13.4	13.2
No. of embryos	10.9	9.8	10.4	10.4	10.4

[a]Means

Table 4. Nitrogen balance of gilts.[a]

	Protein level			Days gestation			Energy level	
Item	8%	14%	20%	30	60	90	M	H
Nitrogen retention (g/day)	10.3	16.6	22.6[b]	13.9	14.6	20.5[b]	14.6	18.0[b]
Retained N (% of digested)	55.3	52.1	48.1[c]	42.0	46.7	67.6[d]	47.1	56.3[e]
Dry matter digestibility (%)	84.3	80.7	78.1[f]	81.6	82.3	79.5	78.5	83.8[f]

[a]Means
[b]Linear effect significant (P<.005).
[c]Linear effect approached significance (P<.10).
[d]Quadratic effect significant (P<.05).
[e]Linear effect significant (P<.025).
[f]Linear effect significant (P<.01).

respectively (Table 4). This linear relationship is similar to that reported by Miller *et al.* (1969) during early gestation, Jones and Maxwell (1974) in early gestation and Jones (1975) throughout gestation.

As energy level increased, nitrogen retention increased with mean values of 14.6 and 18.0 g/day for M and H energy levels, respectively (significant linear effect P<.005). Pike (1970) also showed increasing nitrogen retention with increasing energy levels.

Nitrogen retention increased linearly (P<.005) as stage of gestation progressed with mean values of 13.9, 14.6 and 20.5 for 30, 60 and 90 days gestation, respectively. These data agree with earlier work by Elsley *et al.* (1966) and Kline *et al* (1972) which showed increasing retention from a low value early in gestation to maximum retentions in late gestation. These data suggest that nitrogen retention is increasing at levels of protein higher than those commonly recommended for gestating gilts (14 to 16 percent protein).

Protein retention efficiency decreased with increasing protein level (linear effect, P<.1). Since amino acid ratios are similar across protein levels, this suggests that protein was being supplied in excess of that needed for growth and reproduction, with catabolism and excretion of the excess protein. Retention efficiency increased linearly (P<.025) as energy level increased. Further, there was an increase in retention efficiency as state of gestation progressed, (significant quadratic effect, P<.05) with mean values of 42.0, 46.7 and 67.6 for 30, 60 and 90 days gestation, respectively. Changes in retention efficiency suggest changes in protein synthesis as pregnancy progresses.

Dry matter digestibility decreased as protein level increased (significant linear effect, P<.01) with mean values of 84.3, 80.7 and 78.1 for the 8 percent, 14 percent and 20 percent protein rations. There was no significant trend in dry matter digestibility as stage of gestation progressed. However, dry matter digestibility increased as level of energy intake increased (significant linear effect, P<.01). It appears that energy levels, at least up to the H level of this experiment, can increase dry matter digestibility.

Carcass composition

Carcass weight (Table 5) was not affected by protein level. However, total carcass lean (physically separated) and semimembranosus muscle weight increased as protein level increased from 8 to 14 percent of the diet and no further increase was observed at higher protein levels (significant quadratic effect P<.001 and P<.05, respectively). Liver weight increased linearly (P<.01) as protein intake increased. No significant trends were observed in carcass, semimembranosus muscle on liver weight due to energy.

Table 5. Carcass composition of gilts.[a]

	Protein level			Energy level	
Item	**8%**	**14%**	**20%**	**M**	**H**
Carcass					
Weight (lb)	240.2	253.7	250.1	244	251.7
Lean (lb)	125.6	153.3	146.5[b]	142.1	139.9
Semimembranosus muscle					
Weight (lb)	4.09	4.88	4.60[d]	4.64	4.38
Lean (% of dry wt)	79.6	80.4	80.0	79.4	80.6
Liver					
Weight (lb)	3.39	3.56	4.07[c]	3.53	3.78

[a]Means
[b]Quadratic effect significant (P<.001).
[c]Linear effect significant (P<.01).
[d]Quadratic effect significant (P<.05).

Table 6. Uterine volume, weight and composition.[a]

Item	Protein level 8%	14%	20%	Energy level M	H
Uterine fluid					
Volume (oz)	83.3	74.8	58.9[b]	67.0	72.4
Nitrogen (% of dry matter)	8.2	9.0	9.7[c]	8.8	9.0
Uterine					
Weight (lb)	38.9	35.9	32.3[d]	36.5	35.2

Item	Energy level M, Protein level 8%	14%	20%	Energy level H, Protein level 8%	14%	20%
Uterine						
Dry matter(%)[f]	15.0	13.1	13.3	11.7	16.0	13.4
Nitrogen (%)[eg]	7.7	9.4	9.7	10.2	8.5	9.8

[a]Means
[b]Linear effect significant (P<.05).
[c]Linear effect significant (P<.001).
[d]Linear effect approached significance (P<.10).
[e]Significant (P<.05) energy linear x protein linear interaction.
[f]Significant (P<.01) energy linear x protein quadratic interaction.
[g]Significant (P<.05) energy linear x protein quadratic interaction.

By assuming that the percent protein, percent dry matter and percent lean were the same for the physically separated lean as for the semimembranosus muscle, the total protein content of the carcass was calculated. The average dry ether extract carcass protein values were 23.09, 28.72 and 26.70 lb for the 8, 14, and 20 percent protein levels. Average values for the moderate and high energy levels were 26.11 and 26.23 lb, respectively. These data suggest that total protein stores can be increased by increasing protein levels from 0.32 to 0.56 lb/day.

Uterine weight (Table 6) tended to decrease with increasing protein intake and uterine fluid volume decreased linearly (P<.01) with increasing protein intake. Uterine fluid percent nitrogen increased linearly (P<.001) with increasing protein intake. Total uterine nitrogen was not affected by protein intake, although there was a tendency for uterine protein to increase as protein intake increased at the low energy level but not at the high energy level.

The amount of protein in the uterine tissue (not including nitrogen in the uterine fluid) for the 8, 14 and 20 percent protein levels were 4.31, 4.37 and 3.84 lb, respectively. For the medium and high energy levels, the values were 4.20 and 4.15 lb of protein, respectively. This suggests that the level of protein intake supplied by the 8 percent crude protein diets were as effective as that supplied by the higher levels of nitrogen intake for protein deposition in uterine tissues.

Literature Cited

Elsley, F. W. H., 1966, Anim. Prod. 8:391.

Jones, R. D., 1975, Ph.D. Thesis, OSU, Stillwater.

Jones, R. D., 1974, J. Anim. Sci. 39:1067.

Kline, R. D., 1972, J. Anim. Sci. 35:585.

Miller, G. M., 1969, J. Anim. Sci. 28:204.

Pike, I. H., 1970, J. Agr. Sci. 74:209.

Swine

BREEDING

A Comparison of Mating Systems Utilizing Duroc, Hampshire and Yorkshire Breeds for Swine Production

E. R. Wilson and R. K. Johnson

Story in Brief

This study utilized eight years of crossbreeding data at this station to compare the number of pigs produced by different mating systems using Duroc, Hampshire and Yorkshire breeds. Mating systems were defined to include the purebred and crossbred herds. These were herds required to produce replacement breeding stock for commercial pig production for a particular two-breed terminal, two-breed rotation, three-breed terminal, three-breed rotation or backcross mating scheme.

The best three-breed terminal crossbred system was a Duroc sire mated to a Hampshire-Yorkshire female (D-HY). This system produced 3.8 percent and 2.9 percent more market pigs than Yorkshire X Duroc-Hampshire (Y-DH) and Hampshire X Duroc-Yorkshire (H-DY) crosses. A backcross system using a Yorkshire sire mated to a Duroc-Yorkshire female (Y-DY) produced 2.4 percent more pigs than the D-HY system. The three-breed rotation and Duroc-Yorkshire rotation produced 3.3 percent and 2.9 percent fewer pigs than D-HY respectively. A greater reduction in production as compared to D-HY was predicted for Duroc-Hampshire and Hampshire-Yorkshire rotations which produced 13.0 percent and 7.9 percent fewer pigs, respectively.

The three-breed rotation maintained 91 percent of the farrowing sows in commercial production as compared to 76 percent for D-HY and about 81 percent for the backcross system Y-DY. In the three-breed terminal system D-HY, about 8 percent of the farrowing females were Duroc and about 16 percent were of Yorkshire and Hampshire breeding.

Introduction

The advantage of crossbred pigs and dams for increasing the efficiency of pork production has been accepted by the swine industry. Crossbred pigs reach market weight about 10 days earlier and have approximately 3 percent better feed conversion than purebred pigs. The mating of a purebred female to a boar of another breed will increase the number of pigs per litter at 42-days by about .8 pig per litter and the use of a two-breed crossbred dam mated to a boar of a third breed will increase the number of pigs per litter at 42-days by an additional 1.2 pigs.

In cooperation with USDA, Science and Education Administration, Southern Region.

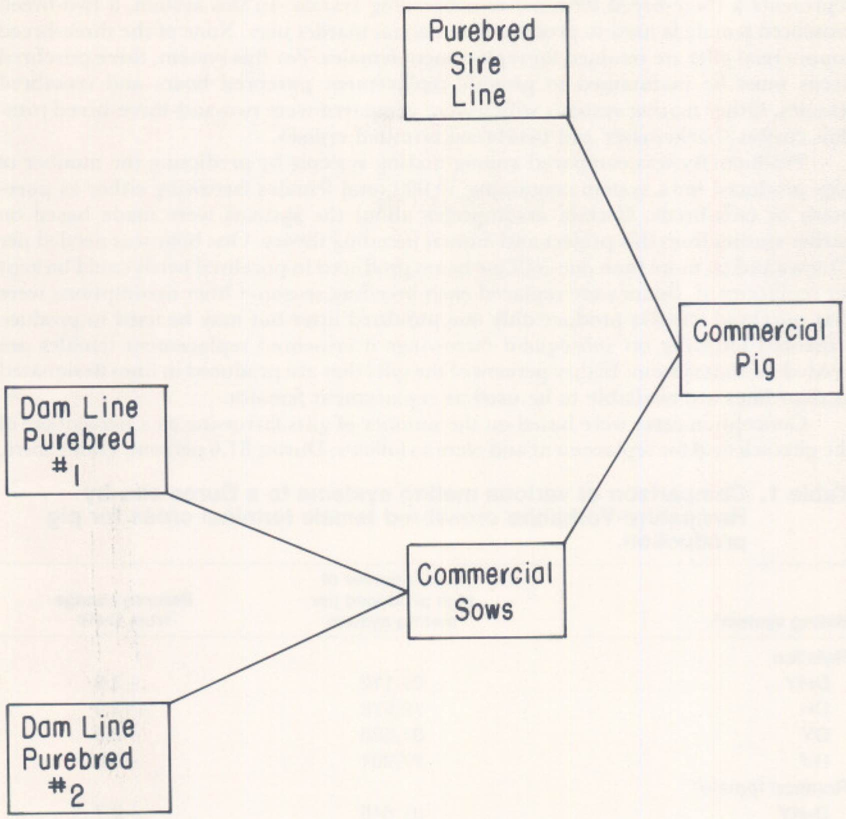


Figure 1. Diagram of three-breed terminal crossbred mating system.

Recommendations to swine producers concerning mating systems have been based on maintaining maximum heterosis for the mating system or for ease of producing replacement females. Many producers have been sacrificing maximum heterosis when they use rotation crossbreeding; however, this system provides the producer with an easy method for supplying replacement females. The object of this study was to compare predicted pig production from three-breed rotation, two-breed rotation, terminal sire on two-breed rotation female, three-breed terminal sire, two-breed terminal sire, backcross and purebred mating systems utilizing Duroc, Hampshire and Yorkshire breeds.

Experimental Procedure

Eight years of crossbreeding data involving Duroc, Hampshire and Yorkshire breeds were utilized in a computer model to compare the productivity of alternative crossbreeding systems involving these breeds. Traits which were considered in this analysis were average number of pigs per litter at 42-days, age at 220 lb, average backfat probe and feed efficiency.

Predicted performances for breeds and breed crosses were used in a computer model to compare productivity of different mating systems. Figure 1 diagrammatically represents a three-breed terminal crossbreeding system. In this system, a two-breed crossbred female is used to produce commercial market pigs. None of the three-breed commercial gilts are retained for replacement females. For this system, three purebred herds must be maintained to provide replacement purebred boars and crossbred females. Other mating systems which were compared were two-and-three-breed rotation crosses, backcrosses and two-breed terminal crosses.

Productivity was compared among mating systems by predicting the number of pigs produced for a system containing 10,000 total females farrowing either as purebreds or crossbreds. Certain assumptions about the systems were made based on earlier studies from this project and animal breeding theory. One boar was needed per 10 sows and no more than one-half the boars produced in purebred herds could be kept for replacement. Boars were replaced each breeding season. Other assumptions were that purebred females produce only one purebred litter but may be used to produce crossbred offspring on subsequent farrowings if crossbred replacement females are needed for that system. Eighty percent of the gilts that are produced in lines designated as dam lines are available to be used as replacement females.

Conception rates were based on the number of gilts farrowing as a percentage of the gilts selected for replacement and were as follows: Duroc, 81.6 percent; Hampshire,

Table 1. Comparison of various mating systems to a Duroc sire by Hampshire-Yorkshire crossbred female terminal cross for pig production.

Mating system[a]	Total number of pigs produced per mating system	Percent change from D-HY
Rotation		
DHY	81,112	−3.3
DH	72,973	−13.0
DY	81,520	−2.9
HY	77,291	−7.9
Rotation female[b]		
D-HY	81,648	−2.7
Y-DH	79,127	−5.7
Three-breed terminal[b]		
H-DY	80,714	−3.8
Y-DH	81,505	−2.9
Backcross[b]		
Y-DY	85,922	2.4
Y-HY	83,099	−1.0
D-DY	80,129	−4.5
D-DH	75,974	−9.5
H-HY	75,224	−10.4
H-HD	73,911	−11.9
Two-breed terminal		
DH	68,373	−18.5
DY	79,390	−5.4
HY	74,945	−10.7
Purebred		
D	59,624	−28.9
H	57,035	−32.0
Y	77,504	−7.6

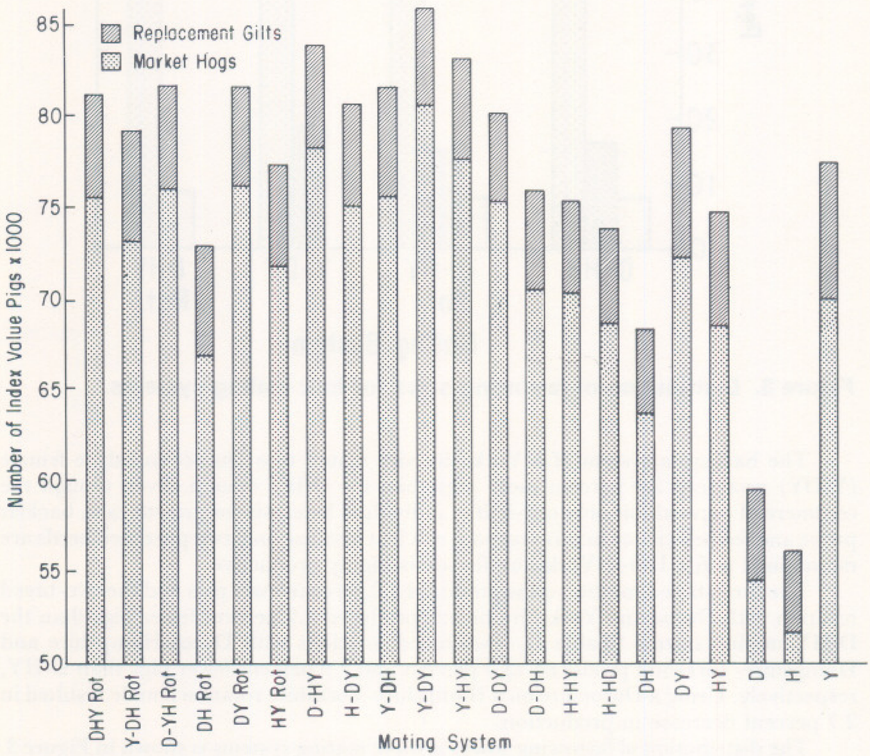
[a]D= Duroc, H= Hampshire, Y= Yorkshire.
[b]Breed of sire listed first.

86 percent; Yorkshire, 70.9 percent; Duroc-Hampshire, 78.1 percent; Duroc-Yorkshire, 83.4 percent and Hampshire-Yorkshire, 82.4 percent. Conception rate was assumed to be the same for gilts and sows. Ninety percent of the gilts which farrowed one litter could be retained in the breeding herd to farrow a second litter. On the average, one-half of the purebred sows farrowing two or more litters and producing crossbred offspring were saved for replacements. An average of 60 percent of the crossbred sows were retained in the breeding herds.

The total number of pigs produced by each breed or breed cross within a mating system was adjusted to compensate for economic differences in production costs and product value due to differences in age at 220 lb, average backfat probe and feed efficiency. Thus, each pig produced in a mating system is of equivalent value. Since each system has an equal number of sows farrowing, the fixed costs for reproduction would be the same for each system. Thus in comparing systems, the system which produces the greatest number of pigs should be the most efficient for swine production.

Results

Figure 2 compares the number of pigs produced by each system. The best three-breed terminal cross was a Duroc sire mated to a Hampshire-Yorkshire female (D-HY). This system produced 3.8 percent and 2.9 percent more pigs than the two other three-breed terminal cross systems, Y-DH and H-DY, respectively, (Table 1).



The average retention rate for purebred sows producing F_1 offspring is .5 and for commercial offspring is six-tenths. The limit of gilts which can be retained for replacements is .8 of female offspring in dam lines.

Figure 2. Number of pigs produced by mating systems.

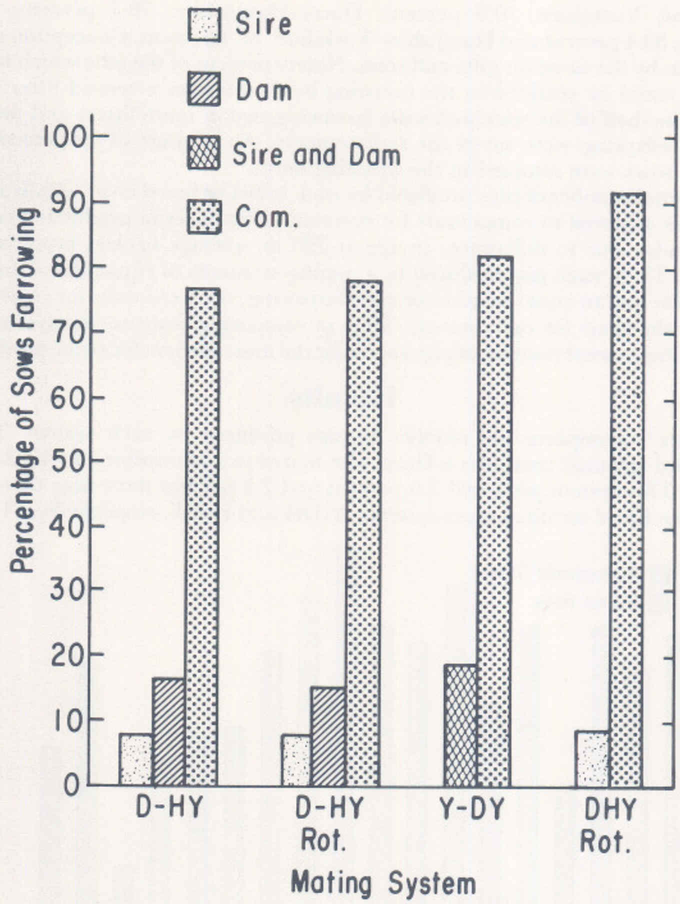


Figure 3. Distribution of farrowing sows for four mating systems.

The backcross system of a Yorkshire sire mated to a Duroc-Yorkshire female (Y-DY) produced 2.4 percent more pigs than the D-HY system. Even though the commercial pigs exhibit only one-half of individual heterosis for growth rate, backfat probe and feed efficiency in this system is efficient because only two purebred herds are maintained and a Duroc-Yorkshire female is highly productive.

The three-breed rotation cross produced 3.3 percent fewer pigs and the two-breed rotation with Duroc and Yorkshire breeds produced 2.9 percent fewer pigs than the D-HY mating system (Table 1). Two-breed rotations with Duroc-Hampshire and Hampshire-Yorkshire produced 13.0 percent and 7.9 percent fewer pigs than D-HY, respectively. Using a Duroc sire on a Hampshire-Yorkshire rotation female resulted in 2.7 percent decrease in production.

The distribution of farrowing sows for three mating systems is shown in Figure 3. The three-breed rotation cross has about 91 percent of farrowing sows as commercial sows as compared to about 76 percent in the D-HY terminal cross. The D-HY system requires about 8 percent of the sows as Durocs and 16 percent as Yorkshire and

Hampshire. In the backcross system Y-DY, Yorkshire breeding is required for both male and female lines so there can be no differentiation between the two lines.

Although this study was based on 10,000 sows, the results should be applicable to producers with small sow herds. In choosing a breeding system a producer must take many items into consideration. This study indicates the need to choose breeds and mating system carefully when trying to improve pork production since some rotation and three-breed terminal crosses appear to have similar efficiencies.

The backcross mating system Y-DY, produced the greatest number of pigs per 10,000 sows. This may not be the situation after long term selection programs. A three-breed terminal cross may be more efficient in the long run since selection can be practiced in specialized sire and dam breeds. Selection in sire and dam lines may produce greater response than general selection for all traits in several breeds. Specialized sire and dam breeds are not possible in a backcross system; thus, a general selection program for productivity, growth and carcass merit must be utilized.

Rotation crosses have the advantage of ease in replacement female production; however, there is reduced production from the best three-breed terminal cross. Also, rotation mating systems do not allow a producer to capitalize on those breeds which are best as dam and sire breeds. A variation of rotation crosses which allows for ease of females replacement and maintaining 100 percent heterosis in the market pig is to mate a terminal sire to a two-breed rotation female. These systems were not as productive as the best three-breed terminal cross however.

A Preliminary Evaluation of Mating Systems Involving Duroc, Yorkshire, Landrace and Spot Breeds Producing Three- and Four-Breed Cross Pigs

L. K. Hutchens, E. R. Wilson, R. K. Johnson, R. L. Hintz, and R. Vencl

Story in Brief

Crossbred and purebred boars were mated to crossbred females involving Duroc, Landrace, Spot and Yorkshire breeds. Conception rate, litter productivity and growth characteristics were compared for the mating systems.

Crossbred boars had a 6.8 percent greater conception rate for first service matings than purebred boars. However, when calculated over matings for the entire breeding season, crossbreds had a 3.1 percent advantage in conception rate.

The comparison of six crossbred female groups indicated that Duroc x Yorkshire and Yorkshire x Landrace females farrowed the largest litters (10.38 and 10.42, respectively). Yorkshire x Landrace females had the highest survival rate to weaning (81.4 percent). Thus at weaning, Yorkshire x Landrace females had litters that were .86 pig larger than any other female group. Litter size and litter weight were similar for purebred and crossbred boars.

Differences for average backfat thickness were small, with ranges from 1.06 to 1.15 inches for sire breed means and 1.08 to 1.12 for dam combinations. Pigs with crossbred

sires were 6.5 days younger at 220 lb than those from purebred sires but probe backfat was essentially the same. In general, mating systems using crossbred boars had a slight overall advantage over mating systems using purebred boars.

Introduction

The superiority of crossbred females as compared to purebred for reproductive traits has been well documented. In addition, crossbred pigs grow faster and are more efficient than purebreds. However, there is little information available concerning the performance of crossbred females of Spot and Landrace breeding.

Previous research at the Oklahoma Agriculture Experiment Station has suggested a higher conception rate and increased libido for crossbred than for purebred boars, suggesting heterosis for male reproductive performance. Therefore, mating systems involving crossbred boars and females of these breeds were investigated.

In 1976, a project was initiated to evaluate the performance of Duroc, Yorkshire, Landrace and Spot breeds as purebreds and in two-, three-, and four-breed crosses. The objectives of the project were to identify mating systems that maximize production efficiency and investigate the effects of crossbred boars. A preliminary comparison of the productivity of purebred females of Duroc, Yorkshire, Landrace and Spot breeding was reported last year (Johnson, 1978). This report is a brief summary of the data collected during the fall 77, spring 78 and fall 78 farrowing seasons. During the first two seasons, growth characteristics were analyzed. Upon completion of the project, a total of five seasons of data will be obtained and a complete analysis will be made.

Experimental Procedure

Crossbred and purebred seedstock used to produce three-breed and four-breed offspring were produced at the Stillwater Experimental Swine Farm by mating purebred boars and females of Duroc, Yorkshire, Landrace and Spot breeding in all combinations. Purebred and crossbred boars were raised in open-front confinement facilities with concrete floors. Boars used in this study were selected within sirebreed groups (reciprocals combined in the case of crossbreds) at 220 lb based upon an index of age and backfat thickness at 220 lbs. The selected boars were transported to the Southwest Livestock and Forage Research Station (SLFRS) and used as herd boars for the next breeding season. The crossbred gilts had been randomly assigned within litter to be fed *ad libitum* in either confinement facilities or on pasture. When gilts reached 200 lb, they were taken off *ad libitum* feed and grouped in pasture lots until detected in estrus and then were sent to SLFRS.

At SLFRS, three boars were utilized from each breed group every season. Purebred boars were mated to crossbred females to produce 3-breed cross progeny and crossbred boars were mated to crossbred females to produce 4-breed cross progeny. Females that returned to estrus during the eight-week breeding season were remated to the same boar. The total number of litters farrowed per breed group is listed in Table 1 and the total number of females exposed to each boar is presented in Table 2. One gilt from each breed group mated to each boar was slaughtered 30 days post-breeding to evaluate embryo liveability and ovulation rate. Only gilts were farrowed the first season. In the subsequent farrowing seasons, about half of the litters were from second litter sows and the remainder were from gilts. A total of 210 gilt and 88 sow litters were utilized in comparisons.

Gestating females were maintained in pasture lots and hand fed a daily ration of about five lb of a 15 percent protein ration. All of the litters were farrowed in a farrowing barn with crates and slotted floors. At approximately one week of age, both the sows and litters were moved to the nursery. Sows and litters were in individual pens until weaning at six weeks of age. Male pigs were castrated at three weeks of age and creep

Table 1. Number of litters representing each mating-type, for the production of three-breed and four-breed crosses.[a]

Breed of sires,[b,c]	No. of sires	Breed of dam[b,c]					
		DxY	DxL	DxS	YxL	SxY	SxL
D	9				13	17	17
Y	9		19	14			12
L	9	15		14		18	
S	9	18	17		16		
DxY	9						19
DxL	9					17	
DxS	9				21		
YxL	9			19			
SxY	9		17				
SxL	9	15					

[a]Farrowed during fall 77, spring 78 and fall 78 farrowing seasons.
[b]Reciprocally produced males and females combined.
[c]D = Duroc, Y = Yorkshire, L = Landrace, S = Spot.

Table 2. Conception rate and number of services per conception for purebred and crossbred boars at SLFRS.

Type of sire	No. of boars	No. of females exposed	% conceived a	% conceived b	No. of services per conception
Purebreds	36	287	78.1	94.8	1.34
Crossbreds	54	188	84.9	97.9	1.22

Spring 77, fall 77 and spring 78 breeding seasons.
[a]Conception rate to first estrus expressed during the breeding period.
[b]Conception rate during the 8 week breeding period.

was made available at that time. At eight weeks of age, the pigs were moved to a confinement finishing facility and fed *ad libitum* to a body weight of 220 lb. At that time, all pigs were probed for backfat and marketed.

Results and Discussion

Conception Rate

The mean conception rates and number of services per conception for purebred and crossbred boars are presented in Table 2. Conception rates for first estrus matings were highest for DxS boars (91.8 percent); however, these were mated entirely to YxL females. Conception rate for first estrus matings was 6.8 percent greater for crossbreds than for purebred boars. However, when all matings of the breeding season were included the advantage was only 3.1 percent for crossbred over purebred boars. Services per conception were greater for purebreds than crossbreds (1.34 and 1.22, respectively).

Litter Productivity

Duroc x Yorkshire and Yorkshire x Landrace females had the largest litter sizes at birth (Table 3; 10.38 and 10.42, respectively). However, only 72.8 percent of the pigs farrowed by DxY females survived to weaning as compared to 81.4 percent for the YxL

Table 3. Litter size and average litter weight for crossbred dams bred to purebred or crossbred boars of another breed.[a]

Breed of dam[b]	No. of litters	Litter size			Survival %[d]	Ave. litter weight at 21-days, lb
		birth[c]	21 days[e]	42 days[e]		
DxY	48	10.38	7.52	7.27	72.8	84.7
DxL	53/52/52	9.98	7.90	7.71	78.5	88.3
DxS	47	10.04	7.40	7.32	74.7	82.8
YxL	50/49/49	10.42	8.76	8.57	81.4	96.0
YxS	52/51/51	9.62	7.24	6.98	75.2	78.3
LxS	48	9.17	7.33	7.06	78.4	82.4
Comparison of Crossbred and Purebred Sires						
Crossbred	108/105/105	9.85	7.64	7.48	77.6	86.24
Purebred	190	9.95	7.73	7.49	76.3	85.13
Standard deviation[f]		2.63	2.26	2.23	19.1	11.2

[a]Litters were produced at SLFRS during spring 77, fall 77 and spring 78 breeding seasons.
[b]Reciprocals combined (DxY = DxY and YxD).
[c]Number of fully formed pigs.
[d]Percentage of fully formed pigs farrowed which survived to weaning at six weeks.
[e]Only litters with more than one pig were included.
[f]From within breed group pooled sum of squares.

Table 4. Average growth rate and probe backfat for three- and four-way cross barrows and gilts of duroc, yorkshire, landrace and spot breeding.

Breed type[b]	No.	Avg. daily gain, lb/day	Age at 220 lb	Probe backfat, in.
	Means by breeding of sire			
Duroc	228	1.56	183.9	1.04
DxY	63	1.59	177.3	1.15
DxL	66	1.54	182.1	1.06
DxS	101	1.64	175.9	1.14
Yorkshire	197	1.60	176.9	1.10
YxL	88	1.60	177.6	1.11
YxS	78	1.55	179.5	1.14
Landrace	202	1.48	189.3	1.15
LxS	73	1.59	176.9	1.11
Spot	248	1.50	187.3	1.12
	Means by breeding of dam			
DxY	216	1.51	186.3	1.12
DxL	239	1.54	181.8	1.11
DxS	212	1.59	177.7	1.12
YxL	276	1.61	178.5	1.10
YxS	203	1.50	188.2	1.08
LxS	198	1.56	182.5	1.10
	4 breed crosses vs. 3 breed crosses			
Crossbreds	469	1.59	178.0	1.12
Purebreds	875	1.53	184.5	1.10
Standard deviation[a]		.230	22.9	.157

[a]From within breed group pooled sum of squares.
[b]Reciprocally produced males and females.

females. Therefore, at weaning YxL litters were .86 pig larger than any other crossbred female group. Duroc x Landrace and Duroc x Spot were intermediate for litter size at birth (9.98 and 10.04, respectively). However, because of a 78.5 percent survival of the pigs farrowed, DxL sows ranked second for litter size at weaning. Yorkshire x Spot and Landrace x Spot dams had the smallest litter size farrowed and raised to weaning.

Average litter weight at 21 days, which is often used as an indicator of the milking ability of the sow, was heaviest for YxL females (96.0 lb). Their average 21 day litter weight was 7.7 lb heavier than for any other breed of dam. Yorkshire x Spot females had the lightest average 21 day litter weight of 78.3 lb. Litter size and litter weight produced by crossbred and purebred boars were similar.

Growth Characteristics

Growth performance and average backfat thickness for the three- and four-breed cross pigs are summarized in Table 4. Considerable differences existed in the mean growth rate for progeny of each sire and dam group. These differences reflect differences in the average genetic make-up of the breeds involved. Additional data will allow more precise estimates of these differences.

Offspring sired by crossbred boars were 6.5 days younger at 220 lb than offspring with purebred sires. The difference between crossbred and purebred boars was very small and nonsignificant for average backfat.

The mating systems involving DxY sires and YxL females were superior for conception rate and litter productivity, respectively. Offspring of DxY sire-breed, and

YxL dam-breed groups also had the fastest growth rate. Crossbred boars had a slight advantage over purebred boars for conception rate, services per conception and offspring growth rate. Purebred and crossbred sires were similar for litter size (at birth, 21 days and 42 days), litter weight at 21 days and average backfat probe of their offspring.

As additional data are collected, a complete analysis will be made and breed differences can be more accurately estimated. These data will then provide information to aid in making decisions concerning breed utilization and mating systems.

Literature Cited

Johnson, R. K., Oklahoma Agri. Exp. Station MP-103:117-119.

Increasing Reproductive Efficiency of Gilts Managed in Confinement

T. A. Hoagland, R. P. Wettemann,
J. E. Minton, C. D. Muncy, R. W. Fent
and C. V. Maxwell

Story in Brief

Sixty-two Yorkshire gilts were used to determine if the absence of estrus in gilts reared in confinement is caused by decreased ovarian response to gonadotropins. Gilts were reared in confinement on concrete floors until 130 days of age then confined in concrete slotted floor pens (8 x 12 ft, eight gilts per pen) or outside lots (60 x 100 ft) until 240 days of age. Gilts were observed daily for estrus starting at 160 days of age. Twenty-four percent of the outside gilts and 18 percent of the confinement gilts exhibited estrus by 210 days of age.

Thirty-two confinement gilts that had not exhibited estrus or ovarian activity by 210 days of age were randomly allotted to treatments: I-Control, II-750 IU PMSG, III-750 IU PMSG and 100 µg GnRH four days later or IV-250 µg estradiol. Percentages of confinement gilts in estrus within six days after treatment were 25.0, 75.0, 87.5 and 0 percent for treatments I thru IV, respectively. Days from treatment to estrus for gilts that responded to treatment were 4.0 ± 1.0, 3.3 ± 0.3 and 4.1 ± 0.3 days for treatments I, II and III, respectively. These data indicate that anestrous gilts in confinement lack cyclic ovarian function but can respond to PMSG treatment with estrus and ovulation.

Introduction

Intensification of swine production has increased the total efficiency of pork production. Confinement, either partial or complete, is an intregral part of intensification. The breeding herd is the last phase of modern production systems to move into confinement. With the construction of total cycle confinement systems, reports of reduced reproductive efficiency of gilts and sows have been widespread. Symptoms reported have included delayed puberty, unwillingness to mate and shortened or lengthened expression of estrus. The net result of these problems has been decreased conception rates, reduced reproductive performance and increased production costs.

This experiment was conducted to determine if delayed puberty associated with total confinement of gilts is caused by altered ovarian response to gonadotropic hormones and to develop hormonal therapy that could be used to initiate puberty in anestrus gilts in confinement.

Experimental Procedure

All gilts were reared in confinement on concrete floors until 130 days of age at the South Swine Barn in Stillwater. Gilts were then confined in concrete slotted floor pens (8 x 12 ft, eight gilts per pen) or outside lots (60 x 100 ft) until 240 days of age. Starting at 160 days of age, gilts were checked for estrus daily using a boar. The boars used for estrus detection were alternated between confinement housing and outside lots every two weeks.

Inside anestrous gilts were randomly allotted to one of four treatments at 210 days of age: I-Control, II-750 IU PMSG, III-750 IU PMSG and 100 µg GnRH four days later or IV-250 µg estradiol. Anestrous gilts were treated during a 10-week period starting in July.

Blood samples were obtained via puncture of the vena cava one week prior to treatment and on the day of treatment. Plasma progesterone was quantified in these samples by radioimmunoassay. The blood progesterone concentrations were used to select anestrous gilts that lacked ovarian activity as well as behavioral estrus. Gilts that exhibited estrus after treatment were inseminated each day of estrus. At 40 days after treatment, the gilts were slaughtered and the numbers of embryos and corpora lutea were determined.

Results and Discussion

Twenty-four percent of the outside gilts and 18 percent of the confined gilts exhibited estrus by 210 days of age. Gilts born during November and December (fall) and maintained outside had a higher incidence of estrus before 210 days of age than gilts born during February and March (spring) (62 percent vs 0 percent respectively, Table 1). The fall born gilts maintained outside were also lighter at 210 days of age than the spring born gilts. Confinement gilts born during the fall and spring had similar body weights and few had exhibited estrus by 210 days of age (Table 1). Perhaps elevated ambient temperature during the summer months delayed the attainment of puberty of the spring born gilts maintained outside.

Anestrous confinement gilts averaged 236.1 ± 4.4 lb and 212.0 ± 1 days of age at treatment. More gilts treated with PMSG and PMSG plus GnRH exhibited estrus within six days after treatment than the controls or estradiol treated gilts (Table 2). Conception rates were similar for the gilts on the three treatments that exhibited estrus, and the numbers of embryos and corpora lutea at day 30 of pregnancy were not influenced by treatment.

Ovarian follicular growth and maturation were stimulated by PMSG treatment. The matured follicles secreted estrogen and caused the onset of standing heat. Ovulation occurred either with or without GnRH treatment after PMSG. Since most anestrous gilts responded to PMSG treatment, it appears that the ovaries were capable of normal function.

These data suggest that confinement gilts not exhibiting estrus by 210 days of age can respond to injections of PMSG and a fertile estrus will be induced. Season of the year when a gilt is born and/or reaches puberty may have an effect on the response to PMSG. Future studies at this station will investigate seasonal effects on puberty in gilts.

Table 1. Influence of confinement on body weight and estrous activity of Yorkshire gilts.

Birth month	Treatment	Number of gilts	Estrus before 210 days		Weight at 210 days
			(no)	(%)	(kg)
November and December	Confinement	15	3	20	242
	Outside	8	5	62	213
February and March	Confinement	25	4	16	230
	Outside	13	0	0	240

Table 2. Reproductive characteristics of anestrous gilts after hormone treatments.

Criteria	Control	PMSG	PMSG & GnRH	Estradiol
No. of gilts	8	8	8	8
No. of gilts in estrus after treatment	2	6	7	0
No. of gilts pregnant to first estrus	2	5	5	0
No. of embryos	14.0	10.8	9.8	- - -
No. of corpora lutea	17.5	15.6	16.4	- - -

Observations on Milk Production of Crossbred Ewes During Three Different Seasons

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Story in Brief

Accelerated lambing results in out-of season lambing. Ewes and lambs involved in accelerated lambing are subject to factors which differ from typical in-season lambing. To obtain data to help determine how ewe's milk producing ability might be affected by accelerated lambing, ewes that were 1/4F, 1/4D, 1/2R; 1/4F, 1/2D, 1/4R and 1/2D, 1/2R were selected from the flocks that had lambed during the fall, winter and late spring. Milk production resulting from these lambings was determined at approximately day 40 and day 70 of lactation.

The experiment involved 125 ewe lactations, using 42, 41 and 42 ewes for the fall, winter and late spring lambings, respectively. Only ewes rearing either single or twin progeny were used.

Seasonal differences for ewe's milk production were found at 40 and 70 days of lactation. Ewes lambing in February had a higher milk production (3.21 lb/24 hr at day 40 of lactation) than ewes lambing in October or June (2.17 and 2.58 lb). Lactation at 70 days for fall lambing ewes was 2.37 lb, with winter and late spring lambing ewes averaging about 1.35 lb.

Milk production for Finn crossbreds was anticipated to be different from the 1/2D, 1/2R. The greatest breed difference was observed for ewes rearing twins. The part Finn ewes which reared twins produced 3.18 lb of milk at about day 40 compared to 2.26 lb for the 1/2D, 1/2R ewes.

Introduction

Profits made in livestock production depend on efficiency. In the sheep industry producers are now considering accelerated lambing (increasing the number of lambings per year) and crossbreeding as methods of increasing the number of lambs

Table 1. Number of ewes of three breeding groups observed rearing single or twin progeny as a result of fall, winter and late spring lambings.

Season of lambing	1/4F, 1/4D, 1/2R Single	1/4F, 1/4D, 1/2R Twin	1/4F, 1/2D, 1/4R Single	1/4F, 1/2D, 1/4R Twin	1/2D, 1/2R Single	1/2D, 1/2R Twin
Fall	5	9	7	7	7	7
Winter	3	12	3	9	5	9
Late Spring	7	7	7	7	7	7
Total	15	28	17	23	19	23

marketed per ewe per year. It is important to determine how well ewes can adapt to these situations. The intent of this experiment was to observe ewe's milk producing ability and determine whether it is influenced by season or breeding of ewes which were various crossbred combinations of Finnish Landrace, Dorset and Rambouillet.

Experimental Procedure

The study involved the lactation curves of ewes that lambed during the three seasons of lambing in the 8-month interval accelerated lambing study under way at the Southwestern Livestock and Forage Research Station near El Reno, Oklahoma. Ewes lambing during the fall (October and November), winter (February and March) and late spring (June and July) were utilized to estimate their daily milk production at about 40 and 70 days of lactation.

The ewes involved in the study were three crossbred combinations: 1/4 Finn, 1/4 Dorset, 1/2 Rambouillet (1/4F, 1/4D, 1/2R), 1/4 Finn, 1/2 Dorset, 1/4 Rambouillet (1/4F, 1/2D, 1/4R) and 1/2 Dorset, 1/2 Rambouillet (1/2D, 1/2R). These ewes were about 4 or 5 years of age and thus considered mature.

To obtain ewes for the milk production study, the peak lambing period for each season was noted and ewes, all of which had lambed within a few days of each other, were selected. Ewes were selected that were rearing either singles or twins. The number of ewes rearing single and twin progeny was kept as nearly the same as possible within the breeds and seasons. Table 1 shows the number of ewes of each breed rearing single or twin progeny for each of the three seasons. Unfortunately there were only 3 ewes available in some breed, rearing and season groups.

The fall lambing occurred in the interval between mid-October and mid-November. The approximate day 40 and day 70 of lactation occurring December 9th and January 6th, respectively. Late February and early March lambing was referred to as winter lambing. On April 4th and May 3rd, data was collected for 40 and 70 days of lactation. The late spring lambing could be considered early summer lambing and occurred primarily in June. Day 40 of lactation was on July 29th and day 70 was on August 26th.

The milk production of the ewes was estimated by determining the milk consumed by their lambs in 24 hours during three nursing periods. The differences between before and after nursing weights for the three periods were added to give the estimated production per day for each ewe. To assure that all ewes would be starting with minimum milk in their udders, lambs were separated from the ewes a day before beginning trials and allowed to nurse at set times. This also aided in conditioning the lambs to the situation. Ewes and lambs were separated for seven and one-half hours (during this time ewes were allowed to graze), and then turned together for 30 minutes allowing lambs to nurse. To minimize lambs nursing the wrong ewes, lambs and ewes were divided by breed resulting in smaller groups. Lambs were deprived of grain and water to help assure suckling.

During the first trial, blankets which covered the whole underside of the ewe were used unsuccessfully for the first two milkings on December 9th. Some lambs appeared to be inhibited and there was trouble encountered in keeping the udder covered on all of the ewes. It is believed that the 40 day estimate for fall lambing is severely underestimated for these reasons.

The fall and winter lambing ewes were grazing wheat pasture at the time of the milk production studies. In all cases, ewes were very adequately fed so that their milk production should not have been adversely affected by pasture or feed conditions.

Results

The results of this experiment are presented in two major divisions. The first division concerns differences for ewe's milk production arising from the ewes being lambed at different times during the year. The second division involves differences due to breed combinations of the ewes. Ewes naturally rear single and twin progeny; therefore, classification by type of rearing was also included.

Season Results

Differences due to season were found by averaging data for each season over breeding groups for ewes rearing singles and twins at about 40 and 70 days of lactation (Table 2). The two lactations were averaged together to give an estimate of total productivity of a ewe. The average milk production for fall and winter lambing ewes was similar, about 2.28 lb. The late spring lambing ewes produced only 1.96 lb.

When considering milk production at about 40 days of lactation, the highest average milk production occurred as the results of February lambing (3.21 lb). The milk production of late spring lambing ewes was expected to be high due to visual observation of ewes' udders but was only 2.58 lb. The fall lambing ewes' production was 2.17 lb but this was probably underestimated due to problems encountered during the trial. (Previous observations of the lactation curve of ewes show a steady decrease in milk production after the second week - not the increase from 40 to 70 days found in the data in this study.)

Differences in milk production due to season also occurred at approximately day 70 of lactation. Fall lambing ewes produced 2.37 lb, with milk production dropping to about 1.35 lb for winter and late spring lambing ewes. The higher production from fall lambing ewes was unexpected since the udders of winter lambing ewes have appeared more distended at weaning than those of ewes weaning fall born lambs.

Breed Results

Interest in using Finnish Landrace in crossbreeding programs is due primarily to the ewes outstanding ability to produce multiple offspring. It was of interest to determine if Finnsheep when used in a crossbreeding program would improve ewes ability to rear multiple progeny.

Data were averaged over seasons by rearing and day of lactation for breed comparisons (Table 3). Overall the ewes could be ranked 1/4F, 1/4D, 1/2R; 1/4F, 1/2D, 1/4R and 1/2D, 1/2R with the milk production being 2.26, 2.15 and 2.09 lb, respectively.

Large breed differences for milk production were primarily seen at day 40 of lactation for ewes rearing twin lambs. The 1/4F, 1/4D, 1/2R and 1/4F, 1/2D, 1/4R ewes outperformed the 1/2D, 1/2R ewes with production at 40 days being 3.40, 2.95 and 2.26

Table 2. Total milk consumption by single and twin progeny of fall, winter and late spring lambing ewes at approximately 40 and 70 days of lactation (lb/24 hr).

	Fall		Winter		Late Spring	
	40*	70	40	70	40	70
Single	1.98	2.11	3.03	1.29	2.28	1.29
Twin	2.35	2.63	3.39	1.41	2.87	1.38
Average	2.17	2.37	3.21	1.35	2.58	1.34
Overall average	2.27		2.28		1.96	

* It is felt these values are underestimated due to problems encountered during the first milk production trial.

lb/24 hr, respectively. This suggests that the part Finn ewes are better able to rear twin lambs when managed as in this experiment. The differences between breeds for ewes rearing single lambs were small at 40 days of lactation.

At 70 days of lactation ewes of all breeds had similar milk production. Milk consumption for lambs which have been creep fed is low enough at 70 days so that no major setback for the lambs results when they are weaned at 70 days.

Table 3. Total milk consumption by single and twin progeny of ewes at approximately 40 and 70 days of lactation (lb/24 hr).

	1/4F, 1/4D, 1/2R		1/4F, 1/2D, 1/4R		1/2D, 1/2R	
	40	70	40	70	40	70
Single	2.38	1.44	2.35	1.58	2.56	1.67
Twin	3.40	1.81	2.95	1.74	2.26	1.86
Average	2.89	1.63	2.65	1.66	2.41	1.77
Overall average	2.26		2.16		2.09	

Summer Lambing Performance of Crossbred Ewes of Finnsheep, Dorset and Rambouillet Breeding when Mated in January to Purebred or Crossbred Rams

J. M. Dzakuma, J. V. Whiteman and J. E. Fields

Story in Brief

Reproductive performance of five, six and seven-year-old crossbred ewes representing six combinations of Finnsheep (F), Dorset (D), Rambouillet (R) and White Face Western (WFW) breeding were evaluated when lambing in the summer (June, 1978). The six breed combinations represented were 3/8F, 5/8WFW; 1/4F, 1/2D, 1/4R; 1/4F, 1/4D, 1/2R; 1/4F, 3/4R; 1/2D, 1/2R and 1/4D, 3/4R. Breeding effectiveness of purebred and crossbred rams of Hampshire and Suffolk breeding was also compared when mated to these ewes.

Results of the summer lambing were quite favorable with the entire flock averaging 1.62 lambs born per ewe exposed. Ewes of 3/8-Finnsheep breeding showed a lambing rate of 2.26 compared to 1.87 for ewes of 1/4-Finnsheep breeding and 1.65 for ewes of only Dorset-Rambouillet breeding. At least 85.7 percent fertility was recorded for each of the crossbred ewes.

In cooperation with USDA, Science and Education Administration, Southern Region.

Reproductive performance of ewes when mated to either purebred or crossbred rams in January-February was virtually the same whether measured by fertility, lambs born per ewe lambing or lambs born per ewe exposed. These results are in contrast to previous findings involving three years of May-June matings. For May-June, 1977 matings, these same ewes when mated to crossbred rams gave birth to an average of 33 more lambs per 100 ewes exposed than those ewes mated to purebred rams.

Introduction

The basic aim of commercial sheep producers is to increase the efficiency of lamb meat production and this can be achieved by increasing the reproductive rate. Two desirable ways of increasing reproductive rate are (1) infusion of germ plasm of more prolific breeds into commercial flocks and (2) adoption of some type of accelerated lambing program to shorten interval between lambings.

The commercial sheep industry of Oklahoma and the Southwest has been built around Rambouillet ewes which are relatively long-lived and shear heavy fleeces but are slow maturing and not very prolific. Past research at the Oklahoma Agricultural Experiment Station has shown that crossbred ewes of Dorset x Rambouillet breeding are more productive under Oklahoma farm flock conditions. Broadening the genetic base of ewe flocks by the introduction from Finland of the Finnish Landrace (Finnsheep) noted for its superior lambing rate, is a possible method of improving the productivity of the commercial sheep of the Southwest.

A program of lambing every eight months (accelerated lambing) may be feasible because ewes have a five-month gestation peroid. Research at this station has shown that ewes of Dorset-Rambouillet breeding produce desirable lamb crops when lambing in the fall, winter or spring and early in the summer.

The purpose of this paper is to report the reproductive performance of five, six and seven-year-old crossbred ewes of Dorset and Rambouillet breeding with similar ewes containing 1/4 and 3/8 Finnsheep breeding when lambing in the summer of 1978. Some data on the breeding effectiveness of purebred and crossbred rams when mated to these same ewes is also included.

Materials and Methods

Approximately 250 crossbred ewes of six combinations of Finnsheep (F), Dorset (D), Rambouillet (R) and White Face Western (WFW) (a group that are predominantly Rambouillet) breeding were produced at the Southwestern Livestock and Forage Research Station (Ft. Reno), El Reno, Oklahoma, during the winter and spring months of 1971, 1972 and 1973. The six breed combinations represented were 3/8F, 5/8WFW; 1/4F, 1/2D, 1/4R; 1/4F, 1/4D, 1/2R; 1/4F, 3/4R; 1/2D, 1/2R and 1/4D, 3/4R. Reproductive performance of some of these ewes when lambing in the winter of 1972, 1973, 1974 and 1977; the fall of 1974, 1975 and 1977; and the summer of 1976 has been reported previously in the Animal Science and Industry Research Reports of 1974-1978.

Ewes nursed their lambs for approximately 70 days after each lambing, except that ewes that lambed late had their lambs weaned at younger ages because of the next breeding season. Condition scores and weights were taken on the ewes each time before breeding and lambing. Scores range from one to nine with a score of one indicating a very thin ewe and a score of nine indicating a very fat ewe.

Prior to January 5, 1978, ewes were divided into single sire breeding groups of 30 to 32 each for breeding which resulted in summer 1978 lambing. Breeding groups were equalized as closely as possible for number of ewes of each crossbred group and for number of ewes rearing zero, one or multiple lambs the previous lambing. A Hampshire, Suffolk, Hampshire x Suffolk or Suffolk x Hampshire sire was placed with each breeding group from January 5 to February 24, 1978. Rams used were about 2-years-old.

Lambing started on May 30, 1978, and continued through June. Ewes lambed under close supervision in a barn or adjacent pasture. After the lambs were about a week old, both ewes and lambs had access to sweet sudan and pearl millet pasture and alfalfa pasture. Dry weather forced the feeding of supplemental ground alfalfa and corn at approximately 3 lb per head per day towards the end of the summer. Lambs had access to creep feed during the preweaning period. The lambs were weaned from their dams at approximately 70 days of age with the exception of late born lambs weaned four to five days before ewes were to be bred for the next lambing.

Results and Discussion

Ewe Reproductive Performance

Lambing performance of the six crossbred ewe groups when lambing in the summer of 1978 are presented in Table 1. For comparison purposes, the lambing performance for the summer of 1976 (previously reported in the 1977 Animal Science Research Report) and the lambing performance in the fall of 1977, when a generally poor lamb crop was obtained (also, previously reported in the 1978 Animal Science Research Report) are presented in the table. Comparisons, therefore, will be discussed between summer 1978 and 1976 lambings, and summer 1978 and fall 1977 lambing.

A flock average of 1.62 lambs born per ewe exposed for summer, 1978, is a slight improvement over the summer of 1976 record of 1.54 lambs born per ewe exposed. The slight improvement of summer 1978 lambing over summer 1976 lambing might be because ewes had a very poor performance in the fall of 1977. Therefore, most of those ewes that did not lamb in the fall of 1977, mated early in January, 1978 and lambed in the summer of 1978. Summer 1978 lambing records indicated 56 single births, 148 sets of twins and 16 sets of triplets. Twenty-six out of the 252 ewes exposed to the rams did not lamb.

Fertility, as measured by percent of ewes lambing, did not differ much for the summer of 1978 and that of 1976. However, three breed groups in the summer of 1976 (3/8F, 5/8WFW; 1/4F, 1/2D, 1/4R and 1/4F, 3/4R) had 100 percent fertility. At least 85.7 percent fertility was recorded in either or the two summer seasons. On the average, summer 1976 fertility was better than summer 1978 fertility (96.2 percent vs 89.7 percent). Fall 1977 average fertility was very poor (38.5 percent) with a high of 51.6 percent for 1/2D, 1/2R ewes.

In the summer of 1978, ewes of 3/8-Finnsheep breeding showed a superior lambing rate (lambs born per ewe lambing) of 2.26 compared to 1.87 for ewes of 1/4-Finnsheep breeding and 1.65 for ewes of only Dorset-Rambouillet breeding. For summer 1976, lambing rates were as follows: 1.96, 1.65 and 1.46, respectively, for 3/8-Finnsheep ewes, 1/4-Finnsheep ewes and Dorset-Rambouillet ewes. In the fall of 1977, lambing rate was 1.38 each for the same ewe groups demonstrating the usual lower lambing rate associated with fall lambing. On the average, lambs born per ewe lambing was higher for summer 1978 (1.81) than summer 1976 (1.60) and was low (1.38) for the fall of 1977.

Lambs born per ewe exposed is an overall measure of reproductive performance and a combination of both fertility and lambing rate. In the summer of 1978, lambs born per ewe exposed for 3/8-Finnsheep ewes, 1/4-Finnsheep ewes and Dorset-Rambouillet ewes were 2.17, 1.68 and 1.45, respectively. For the summer of 1976, the same measures of reproductive performance for the three breed groups were 1.96, 1.61 and 1.38, respectively. During the fall of 1977, the three breed groups produced .46, .45 and .63 lambs per ewe exposed, respectively. It should be noted that for the two summer seasons, 3/8-Finnsheep ewes were superior to 1/4-Finnsheep ewes and 1/4-Finnsheep ewes were in turn superior to ewes of Dorset-Rambouillet breeding. While in

Table 1. Lambing performance of the six crossbred ewe groups when lambing in the summer of 1976, fall of 1977 and summer of 1978.

	3/8F, 5/8WFW	1/4F, 1/2D, 1/4R	1/4F, 1/4D, 1/2R	1/4F 3/4R	1/2D, 1/2R	1/4D, 3/4R	Total
a) Summer 1976 lambing results							
No. available	24	40	47	33	61	56	261
No. lambing	24	40	44	33	58	52	251
% lambing	100.0	100.0	93.6	100.0	95.1	92.9	96.2
Lambs born	47	65	77	51	87	74	401
Lambs/ewe lambing	1.96	1.62	1.75	1.55	1.50	1.42	1.60
Lambs/ewe exposed	1.96	1.62	1.64	1.55	1.43	1.32	1.54
b) Fall 1977 lambing results							
No. available	24	39	47	33	62	52	257
No. lambing	8	13	14	12	32	20	99
% lambing	33.3	33.3	29.8	36.4	51.6	38.5	38.5
Lambs born	11	17	21	16	43	29	137
Lambs/ewe lambing	1.38	1.31	1.50	1.33	1.34	1.45	1.38
Lambs/ewe exposed	.46	.44	.45	.48	.69	.56	.53
c) Summer 1978 lambing results							
No. available	24	35	45	31	68	49	252
No. lambing	23	30	40	30	59	44	226
% lambing	95.8	85.7	88.9	96.8	86.8	89.8	89.7
Lambs born	52	59	75	53	102	68	409
Lambs/ewe lambing	2.26	1.97	1.88	1.77	1.73	1.55	1.81
Lambs/ewe exposed	2.17	1.69	1.67	1.71	1.50	1.39	1.62

Table 2. Lambing performance of the crossbred ewes when mated to purebred and crossbred rams of Hampshire and Suffolk breeding during January-February 1976, May-June 1977 and January-February 1978.

	January-February, 1976		May-June, 1977		January-February, 1978	
	Purebred	Crossbred	Purebred	Crossbred	Purebred	Crossbred
Rams, no.	4	4	4	4	4	4
Ewes exposed, no.	131	130	129	128	126	126
Ewes lambing, no.	127	124	32	67	114	112
Ewes lambing, %	96.9	95.4	24.8	52.3	90.5	88.9
Lambs born, no.	203	198	41	96	205	204
Lambs/ewe lambing	1.60	1.60	1.28	1.43	1.80	1.82
Lambs/ewe exposed	1.55	1.52	.32	.75	1.63	1.62

the fall season, even though reproductive performance was poor with 38.5 percent of ewes lambing, the ewes of only Dorset-Rambouillet breeding were superior to both 3/8- and 1/4-Finnsheep ewes.

All fall lambing results previously reported in Animal Science Research Reports of 1974 and 1975 followed a similar pattern to that shown in Table 1b with ewes of only Dorset-Rambouillet breeding being more fertile than those of part Finnsheep breeding. Considering both summer lambing seasons, 3/8F, 5/8WFW excelled in lambs born per ewe exposed and 1/4D, 3/4R ewes producing fewer lambs.

In all three seasons shown in Table 1 and considering only ewes of Dorset-Rambouillet breeding, the 1/2D, 1/2R ewes outperformed 1/4D, 3/4R ewes in reproductive performance (1.43 vs 1.32) for summer 1976 (.69 vs .56) for fall 1977 and (1.50 vs 1.39) for summer 1978. This is as expected based on how ewes of similar breeding have performed in the past.

Purebred vs Crossbred Rams

Table 2 shows the lambing performance of the ewes when mated to either purebred or crossbred rams in January-February 1976, May-June 1977 and January-February 1978. Winter 1976 and late spring 1977 mating results have been reported previously in Animal Science Research Reports for 1977 and 1978, respectively. They are presented again for comparison with winter 1978 results.

In 1976 and 1978 winter breeding seasons, reproductive performance of ewes mated to purebred or crossbred rams was virtually the same whether measured by fertility (96.9 percent and 95.4 percent vs 90.5 percent and 88.9 percent), lambs born per ewe lambing (1.60 and 1.60 vs 1.80 and 1.82) or lambs born per ewe exposed (1.55 and 1.52 vs 1.63 and 1.62). In the late spring breeding season in 1977, crossbred rams did substantially better than purebreds in fertility (52.3 percent vs 24.8 percent), lambs born per ewe lambing (1.43 vs 1.28) and in lambs born per ewe exposed (.75 vs .32).

In the 1976 Animal Science and Industry Research Report, it was reported that when these same ewes lambed in the fall of 1974 and 1975, ewes mated to crossbred rams gave birth to an average of 19 more lambs per 100 ewes exposed than ewes mated to purebred rams. In 1977 May-June mating, the advantage was 33 more lambs per 100 ewes exposed. The rams tested were approximately 16-months-old at the beginning of the 1974, 1975 and 1977 matings. For the January-February matings of 1976 and 1978, rams tested were approximately 24-months-old.

Since the winter breeding and late spring breeding results do not agree, a possible explanation would be that a high proportion of the ewes were sexually active in January-February in 1976 and 1978; therefore, there was little difference whether a pure-or crossbred ram was used. The fertility in May-June in 1974, 1975 and 1977 might suggest low sexual activity of ewes in these seasons and observations of the flock and mating records verify this fact. In May-June, 1977 matings, 25 ewes did not mate at all to purebred rams and 19 ewes did not mate at all to crossbred rams. Out of a total of 78 ewes that cycled a second time, 43 mated to purebred rams and 35 to crossbred rams. In May-June, 1975 matings, nine ewes did not mate at all to purebred rams and four did not mate at all to crossbred rams, but out of 135 ewes that cycled a second time 58 mated to purebred rams and 77 mated to crossbred rams. In a third cycle, 17 mated to purebred rams and 31 mated to crossbred rams. Two ewes mated in a fourth cycle to crossbred rams. These results suggest that crossbred rams are more agressive in the breeding pastures during the spring than purebred rams, thus the crossbred advantage. These and past results suggest the use of crossbred rams when mating in May-June.

Future Plans

Ewes have been bred in August-September, 1978 to lamb in January-February, 1979. The project will be terminated during the winter of 1979-80.

Whey-Grown Yeast as a Protein Source for Lambs

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Story in Brief

The potential of whey-grown *Kluyveromyces fragilis* yeast as a protein supplement for lambs was studied. Soybean meal or whey-yeast were fed at 11.0 percent or 14.0 percent protein rations to forty 75 lb crossbred ewe lambs in a performance study and to eight ram lambs in a nitrogen balance study. Results of both experiments indicated that, as a supplemental protein source for lambs, the value of whey-yeast was at least equal to that of soybean meal.

Introduction

The search continues for a low cost source of preformed protein which will bypass rumen destruction and yet be highly digestible post-ruminally. The objectives of this study were to determine growth performance, digestibility and nitrogen balance in lambs fed whey-grown yeast or soybean meal as a supplemental protein source.

Materials and Methods

The test product, whey-yeast, was prepared by growing *Kluyveromyces fragilis* (formerly - *Saccharomyces Fragiles)* yeast on cottage cheese whey. Prior to the animal experiments, soluble protein nitrogen of the product was determined at pH 6.5 and 5.5. Ruminal dry matter digestibility and nitrogen digestibility of the whey-yeast were estimated by incubating samples with rumen fluid for 24 hrs.

For the feeding trial, 40 crossbred ewe lambs averaging 75 lb in weight were fed the diets (Table 1) in a six-week growth trial. Lambs were housed in individual feeding pens and allowed a five-day adjustment period during which small amounts of feed were fed. After the adjustment period, feed and water were supplied *ad libitum*. Lambs were weighed full at the end of the adjustment period and then every two weeks thereafter.

In the nitrogen balance trial, eight crossbred ram lambs were fed the same four diets as in the feeding trial. Pairs of lambs were rotated among diets every 14 days until each pair received each of the four dietary treatments. Lambs were housed in individual metabolism stalls and feed and water were supplied free choice. During the last five days of each 14-day period, urine and feces were collected daily and analyzed for nitrogen and dry matter. Rumen fluid samples were obtained, and pH and ammonia concentrations determined. Blood samples were collected and urea-nitrogen content of plasma was determined.

Results and Discussion

Solubility of the whey-yeast protein nitrogen was 2.8 percent at pH 6.5 and 2.3 percent at pH 5.5. Under similar conditions, solubility values of 41, 13 and 7 percent have been reported for dried whey, soybean meal and cottonseed meal, respectively (Wohlt *et al.*, 1973). Values for ruminal dry matter and protein digestibilities of the whey-yeast averaged 28.9 and 20.0 percent, respectively. Corresponding values for soybean meal were 67 and 65 percent. Literature indicates that protein degradation in the rumen tends to increase with protein solubility. With the low nitrogen solubility

Table 1. Composition of the diets used in growth and metabolism trials.

Ingredients*	% Composition (as-fed)			
	Diet no.			
	1	2	3	4
Corn	62.48	64.13	54.18	58.87
Soybean meal	4.51	-	12.81	-
Whey-grown yeast	-	2.86	-	8.12
Cottonseed hulls	25.00	25.00	25.00	25.00
Urea	0.86	0.86	0.86	0.86
Molasses, cane	5.00	5.00	5.00	5.00
Calcium carbonate	0.85	0.85	0.85	0.85
Trace-mineralized salt	0.50	0.50	0.50	0.50
Sodium sulfate	0.50	0.50	0.50	0.50
Potassium chloride	0.30	0.30	0.30	0.30
Crude protein, Nx6.25	11.07	10.97	14.00	13.98
Calcium	0.42	0.42	0.45	0.44
Phosphorus	0.25	0.24	0.28	0.24

* 45,360 IU of vitamin A palmitate and 6, 350 IU of vitamin D were added per 100 pounds of each diet.

Table 2. Growth trial results.

	Diet			
Protein source	Soybean	Yeast	Soybean	Yeast
Protein level, %	11.1	11.0	14.0	14.0
No. of lambs	10	10	10	10
Mean initial wt, lb	76.9^a	73.4^b	77.3^a	73.5^b
Daily feed, lb/day	2.84	2.77	2.91	2.64
Daily gain, lb/day	0.6	0.7	0.6	0.6
Gain: feed ratio	0.2	0.3	0.2	0.2
Daily protein, lb/day	0.31^a	0.30^a	0.41^c	0.37^b
Gain: protein in ratio	1.6^a	2.2^b	1.5^a	1.6^a

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

and low ruminal protein digestibility, it was anticipated whey-yeast protein should resist destruction in the rumen.

Growth trial results are summarized in Table 2. Palatability problems were not observed with any ration. Throughout the experiment, neither source nor level of dietary protein affected rate of gain or efficiency of feed utilization, although the yeast fed lambs averaged 0.5 percent faster gains and 7.2 percent greater efficiency of feed utilization than the soybean meal fed lambs.

Results of the nitrogen balance trial are summarized in Table 3. Diets did not differ statistically in dry matter digestibility but yeast diets averaged 2.8 percent higher in digestibility. The higher (P<.05) nitrogen digestibility coefficients at 14.0 percent protein can be attributed to more supplemental protein and less corn protein in those rations. In the former experiment, the highest rate of gain and protein efficiency ratio was produced by the low nitrogen whey-yeast diet. In this experiment, the highest nitrogen balance was obtained with the same diet. Rumen ammonia nitrogen values tended to be slightly lower with yeast diets. The differences were not large enough to statistically implicate increased protein bypass with yeast diets. Level of protein had no effect on rumen pH but pH was lower with yeast supplementation.

Table 3. Metabolism trial results.

	Diet			
Protein source	Soybean	Yeast	Soybean	Yeast
Protein level, %	11.1	11.0	14.0	14.0
No. of lambs	8	8	8	8
Digestibility %				
Dry matter	65.6	70.0	68.0	69.2
Nitrogen	78.0[a]	80.9[a]	84.3[b]	83.6[b]
Nitrogen retained, g/day	6.0	6.5	8.9	5.1
Rumen ammonia-N, mg/day	20.6	19.4	22.8	21.0
Rumen fluid pH	6.39	6.18	6.34	6.11

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

Little literature information is available regarding whey-yeast as a protein supplement for ruminants. The performance and nitrogen balance data obtained in this study suggest that, as a supplemental protein source, its value is at least equal to soybean meal. Microbial protein is added to or present in certain feedstuffs like fermented whey and liquid supplements for cows on range. Whether microbial protein in liquid supplements is of this high value is not known.

Literature Cited

Wohlt, J. E., 1973, J. Dairy Sci. 56:1052.

Dairy Cattle
NUTRITION and MANAGEMENT

Feeding Value of Reconstituted Sorghum Grain for Dairy Cows

L. J. Bush, G. D. Adams, D. T. Netemeyer and S. A. Jafri

Story in Brief

Rations containing finely ground air-dry and reconstituted (70 percent dry matter) sorghum grain were compared in a feeding trial using 21 lactating dairy cows. The grain comprised 80 percent of a concentrate mixture on a dry basis. This mixture and alfalfa hay were fed in sufficient quantity to provide all the cows would consume, with only the restriction that concentrates comprise no more than 60 percent of the total dry matter intake.

Reconstituted grain was consumed more readily than ground grain, possibly because of the small amount of molasses in the concentrate mixture. Milk yield and composition were similar for cows fed grain processed by the two methods. Apparent digestibility of different components of the ration and gross efficiency of feed utilization were not affected by ration treatments. Reconstituted sorghum grain and finely ground grain were equal in feeding value for high producing dairy cows on a dry basis.

Introduction

The feeding value of reconstituted and finely ground sorghum grain for lactating dairy cows has been compared in two previous experiments. In 1973, workers at Texas A&M reported an increase in actual milk yield and net efficiency of cows fed reconstituted grain compared to cows fed finely ground grain; however, milk fat percentage was decreased. In contrast to previous work at this station (OK MP-96, 1976), milk yield of cows fed reconstituted grain was nearly the same as that of cows fed finely ground grain, and milk fat percentage was slightly higher. No differences were observed in gross or net efficiency of feed utilization. Similarly, other researchers noted no differences in production responses of lactating cows fed high moisture harvested sorghum grain (81 percent DM) preserved with organic acids compared to cows fed dried grain.

In the previous trial at this station, average feed intake and milk yield of cows were lower than desired in current dairy operations, leaving some question about application of the results to high producing herds. Thus, the objective of this study was to compare the feeding value of reconstituted and finely ground sorghum grain for high producing cows.

Materials and Methods

Sorghum grain was reconstituted to 30 percent moisture content and stored anaerobically in double polyethylene bags for at least three weeks prior to feeding. Very little spoilage occurred and the material appeared the same as high moisture grain stored in oxygen-limiting structures. The air-dry grain was finely ground, using a 1/16 inch screen, resulting in particle size of 350 µm geometric mean diameter. Sorghum grain comprised 80 percent of concentrate mixture (Table 1) on a dry matter basis.

Reconstituted grain was rolled before feeding and mixed with an appropriate amount of supplement to give the same proportion of ingredients as in the mixture with ground grain. Alfalfa hay was the sole roughage source for the cows.

During a preliminary period, 21 lactating cows (17 Holsteins and four Ayrshires) were adjusted to a ration of approximately 60 percent grain concentrates and 40 percent hay by limiting the amount of grain to this percentage of total intake. At about eight weeks after calving, the cows were assigned randomly to ration sequences according to a switchback design. The trial consisted of three six-week periods during which each cow received one type of grain, then the other, and finally the original type again.

Sufficient feed was given the cows so that there was refusal of at least 10 percent of either grain concentrates or hay. The only restriction was an attempt to keep the percentage of concentrates from exceeding 60 percent of total dry matter intake.

Milk yields were recorded twice daily, and samples collected at four consecutive milkings each week were composited for determination of milk fat and total solids percentage. Milk fat percentage was determined with a Foss Milko-Tester Mk II, and total solids was determined by drying a 3-ml sample in a forced-air oven for four hrs at 100 C.

Body weights of cows were recorded on three consecutive days at the start of the trial and during the last week of each test period. Digestibility of ration components by 14 cows was determined during the fifth week of each period with chromic oxide as an indicator. Rumen fluid samples were collected from 14 cows three to four hrs after grain feeding during the last week of each period for VFA analysis.

Results and Discussion

Total dry matter intake was similar for cows fed rations containing reconstituted and finely ground dry sorghum grain. However, intake of dry matter as grain concentrates was consistently higher when cows were fed reconstituted grain than when fed ground grain. The apparent advantage in acceptability of the concentrate mixture containing reconstituted grain as compared to the mixture with ground grain was in contrast to results in the previous trial wherein total intake was lower.

The small amount of molasses in the concentrate mixtures used in this trial (Table 1) may have limited acceptability of the dry grain mixture, since concentrate mixtures with finely ground grain and 7 percent dried or liquid molasses were readily consumed by high producing cows in earlier experiments at this station (OK MP-87, 1972).

Milk yield of cows fed reconstituted grain was similar to that of cows fed ground grain (Table 2), even though the reconstituted grain was consumed more readily. Overall, daily yield of the cows in this trial was higher than that observed in similar trials, both at this station and elsewhere, and high enough that the results may be applied to high producing dairy herds. Average milk yield for all the cows at the outset of the trial was 76 lb/day. Cows in both groups gained weight during the trial as expected with the feeding conditions imposed; however, no advantage was noted for either treatment group.

Milk fat and non-fat solids percentages were similar for the two groups. Milk fat test for cows fed reconstituted grain was only slightly lower than that of cows fed dry ground grain which was consistent with observations on molar percentages of rumen VFA.

Although grain concentrates comprised a larger percentage of dry matter intake, on the average, when cows were fed reconstituted grain than when fed dry grain (55.8

Table 1. Composition of concentrate mixture.

Ingredient	Percent
Sorghum grain	80.0
Soybean meal (44%)	10.0
Oats, crimped	7.5
Molasses, liquid	1.0
Dicalcium phosphate	1.0
Salt	.5

Table 2. Responses of cows fed reconstituted and ground sorghum grain.

	Processing method	
Item	Finely Ground	Reconstituted
Feed DM intake		
Grain concentrate, lb/day	23.3	25.0
Alfalfa hay, lb/day	20.8	19.8
Milk yield		
Actual, lb/day	62.5	61.6
Fat, %	3.42	3.34
NFS, %	8.57	8.66
Feed efficiency		
Milk/total feed DM	1.42	1.39

vs. 52.8 percent), the percentage of concentrates exceeded 60 percent in only a few cases. Thus, it appears that no problem with milk fat depression should be expected from feeding cows reconstituted grain where the proportion of concentrates in the total ration is kept within acceptable limits.

Apparent digestibility of total ration dry matter, organic matter and protein were only slightly higher when cows were fed reconstituted grain compared to when they were fed ground grain. Similar results were obtained in a previous trial and are of interest in comparison to other work where sorghum grain comprised a larger percentage of the total ration. It appears that improvement in digestibility of the total ration due to reconstituting sorghum grain can be demonstrated only when the grain comprises a large part of the ration.

Finely ground and reconstituted sorghum grain were found to have equal feeding value on a dry basis. Thus, 100 lb of air-dry finely ground grain would be equal in feeding value to about 125 lb of reconstituted grain. However, reconstituted grain would be expected to be superior to coarsely ground grain, since the latter was 7 to 9 percent lower in feeding value than finely ground grain (OK MP-90, 1973).

Influence of Feeding Cells of *Lactobacillus acidophilus* on the Fecal Flora of Young Dairy Calves

B. B. Bruce, S. E. Gilliland, L. J. Bush, and T. E. Staley

Story in Brief

Newborn dairy calves were removed from their dams after nursing one time. All calves received one additional feeding of colostrum. They were then placed on a diet of pasteurized milk or non-fermented pasteurized milk containing a culture of *Lactobacillus acidophilus* of human intestinal origin or one of calf intestinal origin. During 14-day feeding periods, the numbers of lactobacilli in the feces of calves being fed *L. acidophilus* increased greater than in feces of control calves. The culture of calf origin caused the greatest increase. The increases in numbers of lactobacilli were accompanied by decreases in numbers of coliforms in the feces. The *L. acidophilus* of human origin caused the greatest decrease in numbers of coliforms.

Introduction

Some species of lactobacilli are involved in maintaining a proper balance among microorganisms in the intestinal tract (Sandine et al., 1972 and Speck 1976). Consumption of a product(s) containing viable cells of *L. acidophilus* has been useful in re-establishing the normal intestinal flora after oral antibiotic therapy (Sandine et al., 1972 and Speck 1976) as well in treating patients infected with intestinal pathogens (Tomic-Karovic and Fanjek, 1962). The administration of a non-fermented milk product containing *L. acidophilus* resulted in the appearance of significantly increased numbers of lactobacilli in the feces of healthy men (Gilliland et al., 1978). Some investigators have suggested that there exists host specificity among strains of *L. acidophilus*. Different biotypes of *L. acidophilus* were isolated from humans and chickens (Mitsuoka 1969). A strain isolated from a human could not be implanted in chickens (Morishita et al., 1971).

The objective of this study was to determine the effect(s) of feeding non-fermented milk containing *L. acidophilus* upon the numbers of lactobacilli and coliform bacteria in the intestinal contents of calves during the first one to two weeks of life. Two strains of *L. acidophilus* were compared, one isolated from human intestinal tract and one from the intestinal tract of a calf.

Experimental Procedure

Fifteen bull calves (Holstein or Ayrshire) were assigned to three treatment groups of five calves each. One group, designated as the control group, was fed cold pasteurized whole milk. A second group received cold pasteurized whole milk containing *L. acidophilus* NCFM (a human isolate) and a third group was fed the same milk containing *L. acidophilus* C-28 (a calf isolate).

After birth, the calves were allowed to nurse their dams once. The navel cords of the calves were then swabbed with iodine and covered to help prevent infection while transporting the calves to the experimental area. The calves were placed in individual stalls so that no two calves of the same treatment group were adjacent. A second colostrum feeding was given with a nursing bottle 14 hr after birth. This colostrum was from a supply of frozen pooled colostrum. The feeding of the experimental milks was started with the third feeding. All animals were fed the indicated milk at 12.5 percent of metabolic size ($W^{.75}$) per day. The animals were fed twice daily.

To prepare the experimental milk, cells of *L. acidophilus* NCFM (or *L. acidophilus* C-28) were harvested by centrifugation from cultures grown in lactobacilli MRS broth (Difco). The cells were resuspended in a small amount of cold pasteurized whole milk then sufficient amounts were added to six gallon containers of cold pasteurized whole milk to achieve a population of about 1×10^7/ml. The milk was prepared fresh weekly and stored under refrigeration until fed.

Fecal samples were obtained by rectal stimulation from each animal on days 1, 7 and 14. The samples were collected in unused 8 oz cottage cheese cartons and immediately transported to the laboratory for analysis. Each sample was mixed and diluted with sterile 0.1 percent peptone; the appropriate dilutions were plated with the required media. Lactobacillus Selection Agar (LBS; BioQuest) was used to enumerate lactobacilli and violet red bile agar (VRBA; BioQuest) to enumerate coliforms. The LBS agar plates were incubated in a CO_2 atmosphere 48 hr at 37 C (Gilliland et al., 1978). The VRBA plates were incubated 24 hours at 37 C. The percent dry weight of each sample was determined using an oven drying method. The counts (lactobacilli and coliforms) were calculated on a dry weight basis.

Results and Discussion

Both lactobacillus cultures used to prepare the milk in this study were identified as being *L. acidophilus* using procedures described by Gilliland and Speck (1977). Cells from the same volumes of broth cultures were used to prepare each batch of milk for both strains of *L. acidophilus*. This resulted in the milk containing *L. acidophilus* C-28 having a population of approximately 1×10^7/ml and that containing *L. acidophilus* NCFM having a population of approximately 5×10^6/ml. The populations remained stable for each strain during the period (one week) the milk was held in refrigerated storage while being used in the feeding trial.

The numbers of lactobacilli detected in the feces of the calves increased during the 14-day feeding period for all three groups (Table 1). The increases observed for the control group probably represent the normal development of the intestinal flora in neonatal calves. The average numbers increased greater in the groups being fed milk containing cells of *L. acidophilus* than in the control group. The group receiving milk containing the strain (C-28) isolated from the intestinal contents of a calf exhibited the greatest increase. The difference in results observed using the two strains of *L. acidophilus* from different hosts may be due to host specificity of the strains. The strain (NCFM) from a human did not appear to establish as well as the other strain. Additional experiments will be needed to determine if host specificity occurs among strains of *L. acidophilus*. Greater increases in the numbers of lactobacilli appearing in the feces might occur if higher numbers were added to the milk. In experiments with

Table 1. Average numbers of facultative lactobacilli in feces from young calves being fed non-fermented milk containing *Lactobacillus acidophilus*.

	Lactobacilli[a]/g		
Group	Day 1	Day 7	Day 14
Control	7.50	8.24	8.20
L. acidophilus NCFM (Human Origin)	6.99	7.88	8.57
L. acidophilus C-28 (Calf Origin)	6.84	8.83	9.17

[a]Counts expressed as $\log_{10}$ of count per g dry wt. of feces.

Table 2. Average numbers of coliforms in feces from young calves being fed non-fermented milk containing *Lactobacillus acidophilus*.

Group	Coliforms[a]/g		
	Day 1	Day 2	Day 14
Control	9.52	9.44	9.21
L. acidophilus NCFM (Human Origin)	9.67	9.48	8.67
L. acidophilus C-28 L. (Calf Origin)	9.56	9.40	8.90

[a]Counts expressed as $\log_{10}$ of count per g dry wt. of feces.

humans, the numbers of *L. acidophilus* in milk being consumed influenced the number of lactobacilli that appeared in the feces (Gilliland et al.; 1978).

There was a decrease in the average numbers of coliforms in all groups during the 14-day feeding period (Table 2). The number decreased most in the two groups receiving milk that contained cells of *L. acidophilus*.

As the numbers of lactobacilli appearing in the feces increased (Table 1), the numbers of coliforms decreased (Table 2). This suggests that intestinal lactobacilli may exert an antagonistic action toward coliform bacteria in the intestine of calves. Such an antagonistic action could be very useful in controlling enteric pathogens such as enteropathogenic *Escherichia coli*.

While results in this study suggest a relationship between the numbers of lactobacilli and coliforms in the feces of young dairy calves, additional studies will be needed to determine if administration of *L. acidophilus* as a dietary adjunct can control enteric pathogens. These should include challenging the test animals with a pathogen such as enteropathogenic *E. coli*. Important factors to consider in selecting a *L. acidophilus* for such use are identity and viability of the organism, ability of the culture to survive in the host animal's intestinal tract, and its ability to inhibit enteric pathogens. Cultures of *L. acidophilus* could be evaluated for their ability to inhibit the pathogens in laboratory experiments prior to selecting one for an animal feeding study.

Literature Cited

Gilliland, S. E. and M. L. Speck. 1977. Use of the Minitek system for characterizing lactobacilli. Appl. Envir. Microbiol 33:1289-1292.

Gilliland, S. E., M. L. Speck, G. F. Nauyok, Jr., and F. G. Giesbrecht. 1978. Influence of consuming non-fermented milk containing *Lactobacillus acidophilus* on the fecal flora of healthy males. J. Dairy Sci. 61:1-10.

Mitsuoka, T. 1969. Vergleichende untersuchungen über die Laktobazillen ans der faeces von menchen, seveinen and hühnern. Zbl. Bakteriol. I. Orig. 210:32-51.

Morishita, Y., T. Mitsuoka, C. Kaneuchi, S. Yamamoto, and M. Ogata. 1971. Specific establishment of lactobacilli in the digestive tract of germ-free checkens. Japan J. Microbiol. 15:531-538.

Sandine, W. E., K. S. Muralidhara, P. R. Elliker, and D. C. England. 1972. Lactic acid bacteria in food and health: a review with special reference to enteropathogenic *Escherichia coli* as well as certain enteric diseases and their treatment with antibiotics and lactobacilli. J. Milk and Food Technol. 35:691-702.

Speck, M. L. 1976. Interactions among lactobacilli and man. J. Dairy Sci. 59:338-342.

Tomic-Karovic, V. K. and J. Fanjek. 1962. Acidophilusmilch in der terapie der sauglingsdiarrhoen verursacht durch pathogene *E. coli*. Ann. Paediat. 199:625-634.

Effect of Sour Colostrum on Survival of *Staphylococcus Aureus*

P. B. Barto, L. J. Bush and G. D. Adams

Story in Brief

Staphylococcus aureus is a common cause of bovine mastitis. This preliminary study was designed to determine the effects of sour colostrum on the survival of this organism and factors which are responsible for its destruction.

Two strains of *Staphylococcus aureus*, isolated from cases of bovine mastitis, were inoculated into pooled colostrum of two heifers. The samples were incubated at 22, 30 and 37 C. Daily cultures and pH determinations were made.

Different lengths of time were required for the destruction of the *Staph. aureus* in the fermenting colostrum. Factors influencing their destruction were temperature of incubation, pH and probably antibacterial substances generated by the fermenting bacteria.

Given a sufficient period of time at a temperature permitting fermentation to occur, sour colostrum will destroy *Staph. aureus* and can be fed safely to calves.

Introduction

Feeding colostrum to calves after it has soured is a common practice on dairy farms. It is estimated that 35 to 61 kg (77 to 134 lb) of colostrum are produced by each freshening cow during the first six milkings (Keys, *et al.*, 1976). This is sufficient to feed a 40 kg (88 lb) calf for 11 to 19 days. This practice offers a substantial saving in feed costs.

Normal bacteria present in colostrum are responsible for the souring process. Undesirable pathogenic bacteria can be present in colostrum from infected udders or can gain entrance from the environment. Wray and Callow (1974) showed that *Salmonella typhimurium* and *S. dublin* survived in colostrum for various periods of time. A number of factors were responsible for their destruction. Storage temperature affected the length of survival. Survival time varied in the colostrum of different cows which the authors attributed to natural antibacterial substances. The fall in pH also contributed to the death of the Salmonellae, and antibacterial substances released by the fermenting bacteria exerted an additional killing effect. Salmonellae were completely destroyed at various periods of time during the fermenting process; however, *Escherichia coli* were not affected. They were viable throughout the 40 day experiment.

Contamination of colostrum from the environment with *Salmonella spp*, *E. coli* and other pathogens can be reasonably controlled by employing the same hygienic procedures as are used for collecting and storing grade A quality milk. However, this is not the case for colostrum from infected udders since the pathogenic organisms are already in the colostrum before it is removed from the cow.

There is little evidence that common mastitic organisms cause illness in calves. Schalm (1942) reported that *Streptococcus agalactiae* contaminated milk consumed by heifer calves may contribute to an increased incidence of *Strep. agalactiae* mastitis in these heifers when they freshen. No similar evidence has been reported for *Staph. aureus*. It is contrary to the principles of mastitis control and eradication programs to feed fresh

Table 1. Survival of *Staphylococcus aureus* in fermenting colostrum.

Days of Incubation	22°C pH Control	22°C pH Inoc.[1]	22°C Culture[2]	30°C pH Control	30°C pH Inoc.	30°C Culture	37°C pH Control	37°C pH Inoc.	37°C Culture
0	6.36	6.36	+[3]	6.34	6.36	+	6.34	6.40	+
1	5.20	5.27	+	5.07	5.17	+	4.81	4.84	+
2	4.77	4.73	+	4.98	4.87	+	4.29	4.19	+
3	4.77	4.72	+	4.62	4.49	+	3.89	3.74	+
4	4.68	4.65	+	4.12	4.24	+	3.80	3.56	+
5	4.88	4.62	+	3.97	4.09	+	3.88	3.49	- -
6	4.65	4.76	+	4.08	3.96	- -	4.00	3.62	- -
7	4.71	4.43	- -[4]	4.37	3.94	- -	4.05	3.82	- -
8	5.12	4.52	- -	4.73	3.95	- -	4.29	3.94	- -

[1]*Staph. aureus,* strain N305 was inoculated to give a final concentration of 146,000 organisms per ml of colostrum.

[2]Brain heart infusion broth containing 6.5% NaCl was inoculated with 0.1 ml of colostrum, incubated 1 day then inoculated onto phenyl ethyl alcohol blood agar.

[3]+ = *Staph. aureus* was recovered.

[4]- -= *Staph. aureus* was not recovered.

Table 2. Survival of *Staphylococcus aureus* in fermenting colostrum.

Days of Incubation	22°C pH Control	22°C pH Inoc.[1]	22°C Culture[2]	30°C pH Control	30°C pH Inoc.	30°C Culture	37°C pH Control	37°C pH Inoc.	37°C Culture
0	6.20	6.26	+[3]	6.23	6.27	+	6.26	6.25	+
1	5.40	5.50	+	5.15	5.22	+	4.90	4.93	+
2	5.08	5.07	+	4.72	4.63	+	4.39	4.33	+
3	4.90	4.82	+	4.61	4.48	+	3.92	3.90	+
4	4.79	4.80	+	4.26	4.30	+	3.96	3.90	+
5	4.59	4.54	+	3.86	4.06	- -	3.67	3.77	- -
6	4.63	4.71	+	3.82	4.10	- -	3.56	3.81	- -
7	4.65	4.78	- -[4]	3.85	4.03	- -	3.78	3.98	- -

[1] *Staph. aureus* strain 563 was inoculated to give a final concentration of 244,000 organisms per ml of colostrum.
[2] Brain heart infusion broth containing 6.5% NaCl was inoculated with 0.1 ml of colostrum, incubated 1 day then inoculated onto phenyl ethyl alcohol blood agar.
[3] + = *Staph. aureus* was recovered.
[4] - - = *Staph. aureus* was not recovered.

colostrum containing these mastitis organisms. The feeding of fresh colostrum from infected udders serves to contaminate utensils and equipment with these organisms which in turn may find their way to the udders of the milking herd.

This is a report on a preliminary study of the effect of sour (fermenting) colostrum on the viability of *Staphylococcus aureus*, a common udder pathogen.

Materials and Methods

Colostrum was collected from two heifers for the first six milkings. Quarter samples were collected and cultured. At the end of the collection, the pooled colostrum was cultured. All cultures were negative for *Staph. aureus* and the mastitis group of Streptococci.

The colostrum was thoroughly mixed and poured into clean plastic gallon containers and frozen. As needed a gallon was thawed and following mixing, 100 ml quantities were poured into sterile bottles and refrozen.

For each experiment, six bottles were thawed. Three were inoculated with *Staph. aureus* and three served as controls. Incubation temperatures were 22, 30 and 37 C. Daily pH readings were made on all the samples. Only the inoculated bottles were cultured.

Indirect culture procedures were employed which consisted of inoculating 0.1 ml of colostrum into 6 ml of heart infusion broth containing 6.5 percent NaCl. After 18 to 24 hr incubation, gram stains were made and tube coagulase tests were conducted to confirm the presence of *Staph. aureus*. All cultures were incubated at 37 C.

Results and Discussion

Tables 1 and 2 show the daily changes in pH and the results of culturing for *Staph. aureus*. No great differences in pH occurred between the inoculated sample and corresponding control. In previous experiments attempts to determine the numbers of *Staph. aureus* per ml of colostrum at various stages of incubation were unsuccessful. Additional experiments are necessary to determine if the inoculated *Staph. aureus* increase in numbers during incubation and if they influence the pH values.

Staph. aureus is not recoverable in sour colosturm after a given period of time. *Staph. aureus* survived for longer periods of time at the lower temperature of incubation than at the higher temperature. The pH of the colostrum also appears to have some destructive effect; however, these experiments did not indicate a pH value below which all the *Staph. aureus* would be killed.

The two mastitis strains of *Staph. aureus* had almost identical survival times for each of the three incubation temperatures, even though 40 percent more organisms of strain 563 were inoculated into the colostrum than strain N305.

The results of these experiments are similar to those of Wray and Callow (1974) who reported that the length of survival time of *Salmonella dublin* and *S. typhimurium* in fermenting colostrum was influenced by incubation temperature, pH and probably antibacterial substances generated by the fermenting organisms.

Literature Cited

Keys, J. E., R. E. Pearson and L. A. Fulton. 1976. Fermentation of mastitic milk from antibiotic treated cows. J. Dairy Sci. 59:1746-1751.

Schalm, O. W. 1942. *Streptococcus agalactiae* in udders of heifers at parturition traced to suckling among calves. Cornell Vet. 32:49.

Wray, C. and R. J. Callow. 1974. Studies on the Survival of *Salmonella dublin, S. typhimurium* and *E. coli* in stored bovine colostrum. Vet. Record. 94:407-412.

Studies on Once-Daily Artificial Insemination Programs

Milton Wells and Glenden Adams

Story in Brief

Estrus and insemination records for the past two years were summarized to determine estrus incidence patterns and conception efficiency for cows and heifers in the O.S.U. dairy herd. These were then utilized to develop management recommendations for estrus detection programs and insemination practices relative to time of exhibition of estrus.

Estrus detection was accomplished with visual observation at 8 a.m., 1 p.m. and 5 p.m. with the aid of deviated bulls equipped with Chin-Ball markers. Animals observed at the 8 a.m. and 1 p.m. periods were inseminated in the evening between 4 p.m. and 5 p.m. Animals detected in heat at evening observation were inseminated either in a.m. or p.m. the following day.

Analysis of heat occurrence data revealed that 70 percent to 80 percent of heats will be detected at the 8 a.m. and 1 p.m. observations. Animals cycling in the p.m. conceived equally well whether inseminated the next morning or the following evening. It appears that performing the insemination chores once daily in the evening would be an efficient use of time with no decrease in conception efficiency.

Introduction

For quite a number of years, artificial insemination has been used successfully with efficiency apparently equivalent to natural service. It has been recommended almost universally that cows cycling in the morning be bred in the evening while those cycling in the evening be inseminated the next morning in order to achieve reasonable timing of insemination.

This recommendation is supported by data indicating that there is a fairly long period of time in the estrus period where normal conception efficiency can be expected. Very early breeding or breeding several hours after estrus is over has been thought to contribute to lowered conception efficiency.

Data accumulated in the past few years indicated that dairy cattle do not cycle in a random fashion throughout the day. Data from Canada, Louisiana, California, Kentucky and Oklahoma indicate that 60 to 65 percent of the cows will exhibit heat beginning in the very early hours of the morning up until 8 or 9 a.m.

There have been very few attempts to try to design an insemination program around the heat exhibition pattern. Some limited research as well as uncontrolled field data indicate that once-daily insemination programs may be more acceptable than we have thought for several years.

Methods and Materials

Our research plan was devised to yield information in two basic areas. The first objective was to continue study of the distribution of heats during the 24 hr period. This was important from the standpoint that if the majority of cycling did concentrate in the early morning hours it would dictate an insemination pattern for a once-a-day format. The second objective was to compare the conception efficiency to once-daily inseminations versus twice-daily inseminations.

Our research included heat observations on 492 animals and heat and conception data on 90 heifers and 104 cows. The overall research approach was the same for both heifers and cows. The animals were randomly assigned within breed to one of two study groups.

Group I was subjected to the following insemination pattern: animals cycling in the a.m. and up to 1 p.m. were bred between 3 and 6 p.m. on the same day; animals cycling after 1 p.m. were bred in the p.m. of the following day.

Group 2 animals were designated as our control group and were bred in the traditional format. Animals cycling in the a.m. were bred in the p.m. of the same day while animals cycling in the p.m. were bred in the a.m. of the next day.

Heat detection was accomplished by using deflected bulls equipped with Chin-Ball markers being present in the groups at all times, as well as visual detection three times daily.

Results and Discussion

The results of the heifer study were shown in Table 1. Forty-four heifers were assigned to receive the once-a-day insemination while 46 heifers were to be the controls. In both groups, the high percentage of the first heats observed following the initiation of the study did occur in the a.m. The same pattern held true for the total number of heats exhibited during the breeding program with approximately 75 percent of the heats occurring in the a.m.

It should be realized that this is influenced by the fact that this includes the time period up to 1 p.m. each day rather than the 8 or 9 a.m. which would be typical with twice-daily heat detection.

Conception efficiency in the heifer groups for 1977 is compared in Table 1. The a.m. cycling heifers in both groups conceived in a very similar pattern, requiring 1.68 and 1.72 services per conception, respectively. The p.m. heifers also conceived very similarly, regardless of whether the p.m. cycling heifers were bred the following morning or the p.m. of the following day.

Table 1 also lists the open heifers in each insemination program. The number of open heifers could not be clearly attributed to treatment. Inspection of the data suggested that low bull fertility in two breeds may have contributed to the number of open heifers.

Table 1. Heat and conception data -- heifers, 1977.

	IX-44 Heifers		2X-46 Heifers	
Item	**AM**	**PM**	**AM**	**PM**
1st Heats	30 (68%)	14 (32%)	35 (76%)	11 (24%)
Total Inseminations	47 (73%)	17 (27%)	55 (74%)	19.(26%)
Total Conceptions	28	9	32	10
Services/conceptions	1.68	1.89	1.72	1.90
Conception Rate	59.6%	52.9%	58.9%	52.6%
Open Heifers	2	5	3	1

The heifer data strongly suggests that this type of once-a-day insemination program would impose no penalty on conception efficiency. Although this deviates from the recommendations of previous years, it would appear that it makes little difference whether a p.m. cycling heifer is bred the following morning or the p.m. of the next day.

Table 2 summarizes the results of the study on cows. There were 55 cows in Group 1, which were bred on the once-daily insemination program. There were 49 cows in Group 2 which were bred according to traditional programs. The vast majority of the heats occurred in the a.m. observation period with approximately 80-85 percent of the heats in the cows occurring at the a.m. observation.

Conception data is also presented in Table 2. Conceptions to the a.m. heats were similar for cows bred either twice-daily or once-daily with about 1.5 services required for conception for cows in heat in the a.m. For Group 1, cows cycling in the p.m. and bred the following p.m. required 1.57 services per conception. For Group 2, where the p.m. cows were bred the following a.m., the services required per conception were 1.63.

This data again indicates that it makes little difference whether the p.m. cycling cows are bred the following morning or the afternoon the following day.

Table 3 combines all the data of both cows and heifers. For almost 200 animals, the data strongly indicates that dairy animals can characteristically be expected to be observed in heat predominantly in the morning hours.

Table 2. Heat and conception data --cows, 1977.

Item	1X-55 Cows AM	PM	2X-49 Cows AM	PM
1st Heats	46	9	40	9
Total Inseminations	68	11	59	13
Total Conceptions	45	7	40	8
Services/Conceptions	1.51	1.57	1.48	1.63
Conception Rate	66%	64%	67%	62%

Table 3. Heat and conception data -- all heifers and cows, 1977.

Item	1X-99 Animals AM	PM	2X Animals AM	PM
Total Animals	76	23	75	20
Total Inseminations	115	28	114	32
Total Conceptions	73	16	72	18
Services/Conception	1.57	1.75	1.58	1.78
Conception Rate	63%	47%	63%	56%

Table 4. Recycling patterns on 492 heats, 1977 and 1978.

Pattern	No. Heats	%	%
a.m. - a.m.	307	62	67
p.m. - p.m.	22	5	
a.m. - p.m.	66	13	
p.m. - a.m.	97	20	33

It could be argued that this is a function of our observation times rather than a reflection of the true cycling pattern of the cows. Companion data from Canadian studies indicate that cows truly do come into heat predominantly in the a.m.

Little data is published on whether an animal will exhibit recurring heats in the same part of the day. Table 4 summarizes data on 492 recurring heats. Of these heats, 67 percent were exhibited in the same part of the day as the previous heat, that is, an a.m. -a.m. or p.m. -p.m. pattern.

The balance of the heats, 33 percent, were exhibited in the opposite pattern, that is, a.m. -p.m. or p.m. -a.m. This strengthens our recommendation that extensive morning heat observations are most critical for excellent heat detection programs.

On a practical management viewpoint, there could be little doubt that a big percentage of the cows can be found in heat by observing up to 1 p.m. each day. Our data also strongly suggests that these animals can be efficiently inseminated by breeding them at 3 to 5 p.m. in the afternoon, and that a.m. cycling animals may conceive more efficiently than p.m. cycling animals.

If true, this is likely a function of timing and suggests that insemination early in the heat period may not be as big a penalty as has been thought. Although the total number of animals cycling in the p.m. is limited, there is a strong indication that it makes little difference whether p.m. cycling cows are bred the following morning or in the afternoon of the following day.

At first inspection, this may seem contrary to insemination recommendations that have been made for years. However, if we examine the time line in Figure 1, it becomes quite apparent that a.m. cycling cows are bred essentially from mid to late cycle while p.m. cycling cows bred the following p.m. are bred toward the very end of the expected standing heat period.

When this fact is realized, then it is not surprising that p.m. cycling cows bred the following p.m. should not be suffering any penalty in terms of conception efficiency. It should also be realized that p.m. cycling cows bred the following p.m. will still be inseminated several hours prior to ovulation. Our results suggest that the time period is adequate for sperm cells to be prepared for fertilization.

More studies need to be conducted on this, but we have little hesitancy at the moment in recommending once-a-day insemination as defined in this study.

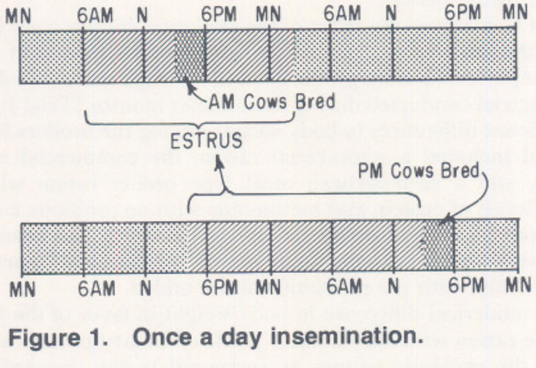

Figure 1. Once a day insemination.

POULTRY NUTRITION

Evaluation of a Commercial Probiotic Culture in Broiler Rations

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Story in Brief

Two eight-week feeding trials were conducted using a commercial strain of chicken broilers. The first feeding trial (Trial I) was completed during the summer of 1978 (June 13 to August 1) when the maximum environmental temperature each day approached or exceeded 100°F. The second feeding trial (Trial II) was held during the fall of 1978 (October 17 to December 12) when environmental conditions from a temperature standpoint were in the range from 30 to 85°F.

The broiler rations fed included a standard commercial broiler ration currently being used under practical production conditions, as well as, corn-soybean meal type broiler rations without fish meal or feather meal which had been formulated to contain both marginal and adequate levels of dietary protein and methionine. These rations were fed with and without the addition of a commercial probiotic culture in order to obtain comparative data.

The purpose of these two feeding trials with broilers was (1) to determine if a probiotic culture as prepared and sold commercially when added to broiler rations with substandard dietary nutrient levels would increase rate of growth and improve efficiency of feed utilization, and (2) to determine if such a probiotic culture would alleviate the stress imposed on broilers when environmental temperatures exceed 90 to 95°F during the growing period.

Criteria used to measure the effect of the probiotic culture were body weight at intervals during the growing period, efficiency of feed utilization at the same time intervals, feed cost per lb of broiler produced at market age and dressed market grade.

In the feeding trial conducted during the summer months (Trial I), there were no statistically significant differences in body weight among the broilers fed the different rations. This trial included a commercial ration, the commercial ration plus the probiotic culture, and a corn-soybean meal type broiler ration which contained adequate dietary levels of protein and methionine with no probiotic culture. In addition, a corn-soybean meal type broiler ration was fed which had been formulated to contain dietary levels of protein and methionine at 87 percent and 79 percent of dietary standards, respectively, with the probiotic culture added.

There was a numerical difference in body weight in favor of the broilers fed the corn-soybean type ration with substandard levels of dietary protein and methionine which contained the probiotic culture as compared to the unsupplemented corn-soybean type ration which contained adequate protein and methionine. However, the broilers fed this ration were not equal to those fed the commercial ration or the commercial ration plus the probiotic culture insofar as body weight was concerned.

The addition of the probiotic culture to the commercial ration did not increase body weight or improve efficiency of feed utilization as compared to the results obtained when no probiotic culture was fed. In addition, a statistically significant difference ($P < .05$) in lb of feed per lb of broiler produced was observed in favor of the commercial ration and the commercial ration plus the probiotic culture.

The results from Trial I lead to the conclusion that efficiency of protein and methionine utilization may have been enhanced by the addition of the probiotic culture as indicated by body weight. Under the conditions of Trial I, the addition of the probiotic culture did not improve growth rate or increase efficiency of feed utilization when added to a ration calculated to be nutritionally adequate in every respect. A comparison of feed cost per lb of broiler produced (Trial I) shows that there was no economic advantage to be gained under the conditions of this feeding trial in supplementing with the commercial probiotic culture.

In Trial II, a series of broiler rations was formulated with both cost and nutritional adequacy being taken into consideration. On one end of the series, nutritional adequacy was obtained at an economically feasible ingredient cost (broiler ration used under practical production conditions). At the other end of the series, ingredient cost was given primary consideration and nutritional adequacy in terms of total dietary protein, dietary methionine level and dietary energy level as allowed to drop below accepted nutritional standards.

In this trial (Trial II), statistically significant differences ($P < .05$) in both body weight and efficiency of feed conversion were observed among the broilers fed the eight experimental rations. A cost analysis based upon ingredient cost and expressed in terms of feed cost per lb of broiler produced did not justify the use of the commercial probiotic culture as a supplement to any ration regardless of its position in the formulation series.

There were no differences among any of the broilers in either trial insofar as market grades were concerned in terms of fleshing and finish. Thus, it can be concluded that the treatments imposed had no adverse effect.

Introduction

Considerable interest is being shown by poultrymen at the present time in commercial probiotic cultures for use in poultry feeds of all kinds. Published research data with broilers and growing turkeys give some indication that the addition of certain lactobacillus cultures does improve the efficiency with which dietary protein is utilized, particularly when total dietary protein level is substandard. Along this same line, it would appear that a substantial deficiency of dietary methionine, expressed as a percentage of total protein and as much as 20 percent below requirements, can be overcome to a major degree when lactobacillus cultures are added to the ration. In addition, less desirable organisms in the intestinal tract are thought to be replaced by the lactobacillus.

Observations made under practical feeding conditions lead to the conclusion that the various forms of stress which are encountered under commercial production conditions may be alleviated to some degree through the use of commercial probiotic cultures which contain certain lactobacillus cultures among other microorganisms. These stresses include, among others, high bird density, exposure to disease producing organisms and high environmental temperature in excess of 95°F.

Modern poultry management systems are designed to obtain a maximum return per dollar invested. In many instances the procedures followed do not provide for optimum environmental conditions and/or they increase the risk that major production problems will be encountered. As a result, a calculated risk imposed by these stresses will not offset the economic advantages to be gained. Poultrymen are always ready to adopt new feeding or management practices by means of which these stresses can be alleviated at a minimum cost, and the overall risk of production can be reduced.

Commercial probiotic cultures are being manufactured, and a number are being offered for sale in Oklahoma. For this reason, a series of experiments was conducted for the purpose of obtaining data upon which to base some sort of an evaluation of this type of commercial probiotic culture when it is added to a broiler ration.

The two primary objectives of the studies reported herein were (1) to determine if a commercial probiotic culture would increase the efficiency with which total protein and methionine could be utilized, and (2) to determine if the adverse effect of stress (in this case high environmental temperature) could be alleviated. Lowering total dietary protein level and reducing the need for supplemental methionine would be instrumental in reducing ration cost, assuming the efficiency with which these nutrients are utilized was increased (first objective). If stress can be alleviated (second objective), overall production costs related to environment (high bird density, environmental temperature, and disease exposure, among others) might be substantially lowered.

Material and Methods

The housing environment for each of the two feeding trials reported in this paper was the same except that Trial I was conducted in June and July and Trial II in October, November and December. The broilers were housed in 6 x 12 foot pens equipped with infrared brooders, suitable size water fountains and feeders. The pens were arranged on either side of a central isle which adapted well to the randomized block design which was employed in both feeding trials. Standard management practices were followed in caring for the broilers during the entire experimental feeding period.

The same commercial broiler strain was used in both feeding trials and was obtained from a commercial hatchery in Arkansas. Each experimental pen consisted of 15 male and 15 female broilers. The pens on one side of the central isle in the broiler house were considered to be a block (two blocks in the house) and all the experimental rations within a given feeding trial were randomly assigned to each of the two blocks.

The four experimental rations fed in Trial I and the eight experimental rations fed in Trial II are listed in Tables 1, 2 and 3. Emphasis was placed on Trial I on determining the effect of the commercial probiotic culture when added to a commercial broiler ration currently being fed under practical feeding conditions (Table 1, Rations 1 and 2). This was compared to broiler rations (basically corn-soybean type with no fish meal or feather meal) which contained dietary protein and dietary methionine at levels at or below accepted dietary requirement standards (Table 1, Rations 3 and 4). The environmental stress in this case was a daily environmental temperature in excess of 95°F (summer growing conditions).

The approach in Trial II, on the other hand, was to formulate and feed a series of broiler rations with different degrees of nutritional adequacy, both with and without the addition of the commercial probiotic culture. These rations were formulated with consideration being given to both nutritional adequacy and cost. A balance was selected in the case of each experimental ration so that nutritional adequacy was given preference at one end of the series (Table 2 and 3, Ration 1) with cost being what it had to be to meet standards for total dietary protein and dietary methionine. On the other hand, preference was given to the other end of the series (Table 2 and 3, Ration 8) to getting cost as low as possible at the expense of total dietary protein and dietary methionine.

Measurements taken included body weight and feed consumption at the end of three, six, and seven weeks of the growing period in Trial I and at the end of two, four, six and eight weeks in Trial II. Mortality was recorded daily. The broilers were

Table 1. Experimental rations Trial I.

Ingredients	Ration number 1 Starter (%)	1 Finisher (%)	2 Starter (%)	2 Finisher (%)	3 Starter (%)	3 Finisher (%)	4 Starter (%)	4 Finisher (%)
Tallow, feed grade	5	5	5	5	7	7	4	7
Yellow corn, ground	54.1	59.53	54.1	59.53	41.55	49.05	48.15	45.15
Soybean meal (44%)	29	25	27	23	35	28	33	33
Alfalfa meal (17%)	- -	- -	- -	- -	3	3	3	3
Dried whey (12%)	- -	- -	- -	- -	3	3	3	3
Fish meal (menhaden)	4	4	4	4	- -	- -	- -	- -
Feather meal	2	2	2	2	- -	- -	- -	- -
Live yeast culture (14%)	- -	- -	- -	- -	3	3	3	3
Meat & bone meal (50%	4	2.5	4	2.5	5	5	- -	- -
dl Methionine	0.15	0.12	0.15	0.12	0.1	0.1	- -	- -
Phosphorus supplement (Ca27-P18)	0.6	0.7	0.6	0.7	1.0	1.0	2.0	2.0
Calcium carbonate	0.5	0.5	0.5	0.5	0.5	- -	1.0	1.0
Trace mineral mix[1]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Salt	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5
Broiler vitamin mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Commercial probiotic culture (soybean meal carrier)[3]	- -	- -	2	2	- -	- -	2	2
Calculated analysis								
Protein (%)	23.9	21.9	23.9	21.9	23.0	20.6	21.0	20.7
Methionine (% of protein)	2.26	2.20	2.26	2.20	1.98	2.00	1.59	1.50
Kcal/lb	1437	1434	1437	1434	1346	1408	1299	1376

[1]Provides in the ration: manganese 120 ppm; zinc 80 ppm; iron 60 ppm; copper 10 ppm and iodine 1.0 ppm.

[2]Contains per pound of vitamin mix: vitamin A 1,400,000 I.U.; vitamin D_3 320,000 I.U.; vitamin E 1,400 I.U.; menadione sodium bisulfite complex 800 mg; riboflavin 1,400 mg; niacin 7,000 mg; d-pantothenic acid 2,000 mg; choline 110,000 mg; thiamine 200 mg; pyridoxine 200 mg; vitamin B_{12} 2.2 mg; d-biotin 20 mg; and folic acid 140 mg.

[3]Combination of *Lactobacillus acidophilus, Lactobacillus casei, Bacterium bifidus, Torulopsis,* and *Aspergillus oryzae.*

Table 2. Experimental starter rations Trial II.

	Ration number							
	1	2	3	4	5	6	7	8
Ingredients	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Tallow, feed grade	5	5	2.5	2.5	5	5	3	3
Yellow corn, ground	53.75	53.75	59.87	59.87	45.45	45.45	49.05	49.05
Soybean meal (44%)	29	27	26.2	24.2	33	31	35	33
Fish meal (menhaden)	4	4	3.4	3.4	- -	- -	- -	- -
Feather meal	2	2	1.7	1.7	- -	- -	- -	- -
Meat and bone meal (50%)	4	4	3.4	3.4	5	5	- -	- -
Alfalfa meal (17%)	- -	- -	- -	- -	3	3	3	3
Dried whey (12%)	- -	- -	- -	- -	3	3	3	3
Live yeast culture (14%)	- -	- -	- -	- -	3	3	3	3
dl Methionine	0.15	0.15	0.13	0.13	0.1	0.1	- -	- -
Phosphorus supplement (Ca27-P18)	0.6	0.6	1.6	1.6	1.0	1.0	2	2
Calcium carbonate	0.75	0.75	0.35	0.35	0.5	0.5	1.0	1.0
Trace mineral mix[1]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Salt	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5
Broiler vitamin mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Coban	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Commercial probiotic culture (soybean meal carrier)[3]	- -	2	- -	2	- -	2	- -	2
Calculated analysis								
Protein (%)	23.9	23.9	22.3	22.3	22.4	22.4	21.1	21.1
Methionine (% of protein)	2.25	2.25	2.22	2.22	2.00	2.00	1.58	1.58
Kcal/lb	1404	1404	1367	1367	1317	1317	1279	1279

[1]Provides in the ration: manganese 120 ppm; zinc 80 ppm; iron 60 ppm; copper 10 ppm and iodine 1.0 ppm.

[2]Contains per pound of vitamin mix: vitamin A 1,400,000 I.U.; vitamin D_3 320,000 I.U.; vitamin E 1,400 I.U.; menadione sodium bisulfite complex 800 mg; riboflavin 1,400 mg; niacin 7,000 mg; d-pantothenic acid 2,000 mg; choline 110,000 mg; thiamine 200 mg; pyridoxine 200 mg; vitamin B_{12} 2.2 mg; d-biotin 20 mg; and folic acid 140 mg.

[3]Combination of *Lactobacillus acidophilus, Lactobacillus casei, Bacterium bifidus, Torulopsis,* and *Aspergillus oryzae.*

Table 3. Experimental finisher rations Trial II.

Ingredients	Ration number 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)
Tallow, feed grade	5	5	1.5	1.5	2	2	1.5	1.5
Yellow corn, ground	59.5	59.5	67.1	67.1	56.5	56.5	56.6	56.6
Soybean meal (44%)	25	23	22	20	27	25	29	27
Fish meal (menhaden)	4	4	3.4	3.4	- -	- -	- -	- -
Feather meal	2	2	1.7	1.7	- -	- -	- -	- -
Meat & bone meal (50%)	2.5	2.5	2	2	2	2	- -	- -
Alfalfa meal (17%)	- -	- -	- -	- -	3	3	3	3
Dried whey (12%)	- -	- -	- -	- -	3	3	3	3
Live yeast culture (14%)	- -	- -	- -	- -	3	3	3	3
dl Methionine	0.12	0.12	0.1	0.1	0.1	0.1	- -	- -
Phosphorus supplement (Ca27-P18)	0.7	0.7	1.0	1.0	2	2	2	2
Calcium carbonate	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
Trace mineral mix[1]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Salt	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5
Broiler vitamin mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Coban	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Commercial probiotic culture (soybean meal carrier)[3]	- -	2	- -	2	- -	2	- -	2
Calculated analysis								
Protein	21.9	21.9	20.3	20.3	19.3	19.3	19.1	19.1
Methionine (% of protein)	2.20	2.20	2.17	2.17	2.12	2.12	1.61	1.61
Kcal/lb	1437	1437	1385	1385	1293	1293	1263	1263

[1]Provides in the ration: manganese 120 ppm; zinc 80 ppm; iron 60 ppm; copper 10 ppm and iodine 1.0 ppm.
[2]Contain per pound of vitamin mix: vitamin A 1,400,000 I.U.; vitamin D_3 320,000 I.U.; vitamin E 1,400 I.U.; menadione sodium bisulfite complex 800 mg; riboflavin 1,400 mg; niacin 7,000 mg; d-pantothenic acid 2,000 mg; choline 110,000 mg; thiamine 200 mg; pyridoxine 200 mg; vitamin B_{12} 2.2 mg; d-biotin 20 mg; and folic acid 140 mg.
[3]Combination of *Lactobacillus acidophilus, Lactobacillus casei, Bacterium bifidus, Torulopsis,* and *Aspergillus oryzae.*

processed and given a dressed market grade for both fleshing and finish at the end of seven weeks in Trial I and eight weeks in Trial II. From the body weight and feed consumption data, calculations were made for feed cost per lb of broiler produced.

Results and Discussion

Data on body weight, efficiency of feed conversion and feed cost per lb of broiler produced which were obtained when the broilers were six-weeks-old are listed in Table 4. A statistical analysis of these data indicates that there were no statistically significant differences in body weight among the broilers fed the four experimental rations. However, it did require more lbs of feed per lb of broiler for the broilers fed Rations 3 and 4 than it did for the broilers fed Rations 1 and 2 ($P < .05$).

Even though there were no statistically significant differences in body weight, the broilers fed Ration 4, which contained the commercial probiotic culture, were substantially heavier than those fed Ration 3. Since Ration 4 was formulated to be substandard in both total protein and methionine, it would appear that the addition of the commercial probiotic culture improved the efficiency with which these two nutrients were utilized. On the other hand, it must be noted that the addition of the commercial probiotic culture did not improve the growth performance of the commercial broiler ration (Table 4, Ration 1 vs Ration 2) as measured by either body weight or lbs of feed per lb of broiler produced.

The real consideration of the broiler producer is feed cost per lb of broiler produced. For this reason, an analysis of feed cost was made utilizing values for body weight and lbs of feed per lb of broiler produced which were obtained when the broilers were six-weeks-old. Only ingredient cost was included in making these calculations. A summary of this analysis is presented in Table 4.

Table 4. Body weight, feed conversion and feed cost data at 6 weeks of age Trial I.

Ration number	Body weight (lb)	Lb feed per lb of broiler	Total feed cost[1] per broiler (cents)	Feed cost per lb of body weight (cents)
1-Commercial	2.95	1.89	41.80	14.17
2-Commercial plus probiotic culture	2.81	1.90	43.15	15.36
3-Corn-soybean type (adequate)	2.63	2.05	42.45	16.14
4-Corn-soybean type (deficient) plus probiotic culture	2.73	2.08	44.91	16.45

[1]Ingredient cost only.

The commercial broiler ration produced a lb of broiler at the lowest feed cost among the four rations which were compared. Feed cost per broiler for Ration 4 was the highest among the four with Ration 2 and 3 intermediate. Even though some increase in efficiency of nutrient utilization may be apparent, the additional cost imposed by the probiotic culture is not offset by the improved growth performance.

Data obtained in Trial II for body weight, lbs of feed required per lb of broiler produced and feed cost per lb of broiler produced are presented in Table 5. A statistical analysis indicates that there are statistically significant differences ($P < .05$) in both body weight and efficiency of feed conversion in favor of Ration 1 (unsupplemented

Table 5. Body weight, feed conversion and feed cost data at 6 weeks of age Trial II.

Ration number	Body weight (lb)	Lb feed per lb of broiler	Total feed cost[1] per broiler (cents)	Feed cost per lb of body weight (cents)
1-Commercial	3.41	1.99	57.31	16.81
2-Commercial plus probiotic culture	3.28	2.05	58.00	17.68
3-Commercial 85%	3.21	2.13	52.71	16.42
4-Commercial 85% plus probiotic culture	3.21	2.12	53.91	16.79
5-Corn-soybean meal type (adequate)	3.05	2.26	55.33	18.14
6-Corn-soybean meal type (adequate) plus probiotic culture	3.05	2.29	57.16	18.74
7-Corn-soybean meal type (deficient)	3.07	2.29	53.32	17.37
8-Corn-soybean meal type (deficient) plus probiotic culture	3.12	2.33	56.77	18.79

[1]Ingredient cost only.

commercial). There was a progressive decrease in both body weight and efficiency of feed conversion from Ration 1 through Ration 8.

Under the conditions of Trial II, there was no advantage either from a growth performance standpoint or an economic standpoint in supplementing any one of the four rations (Rations 1, 3, 5 and 7) with the probiotic culture. It must be pointed out, however, that if environmental stress such as was encountered in Trial I with the high ambient temperature had been imposed in Trial II, growth performance might have been improved with Ration 8 over Ration 7 (Trial II). This was observed to some degree in Trial I with Ration 4 over Ration 3. It is difficult to simulate the stresses inherent in commercial production situations when feeding trials are conducted under controlled experimental conditions.

It should be noted also that the lowest feed cost per lb of broiler produced (Trial II) was obtained with Ration 3, and even the feed cost for Ration 4 was slightly below that for Ration 1. This leads to some speculation that based upon economic considerations, protein quantity and quality might be excessively high in the commercial ration.

A summary of the dressed grades for fleshing and finish are not presented in a table for the reader's consideration. However, from the results which were obtained, the treatments which were imposed had no adverse effect on dressed market grade.

MEAT and CARCASS EVALUATION

The Influence of Changes in Muscle DNA Content and Nuclear Number on Muscle Growth in Feedlot Cattle

J. J. Guenther, R. D. Morrison

and K. K. Novotny

Story in Brief

DNA, nuclear number and fiber width were determined on longissimus dorsi sections obtained from Hereford and Charolais crossbred steers slaughtered at 500, 700 and 900 lb. Results showed a significant decrease in longissimus DNA concentration with increased feedlot weight. This appeared to suppress the rate of growth of the longissimus muscle as well as the individual muscle fibers, particularly after the 700 lb slaughter period. Nuclear number increase also diminished after the animals had reached 700 lb live weight, suggesting that the amount of muscle tissue and cell volume supported per nucleus had increased with feedlot weight. Results indicated that the longissimus muscle from these experimental animals approached biological maturity at about 700 lb live weight and that this was related to the DNA concentration in the muscle.

Introduction

Deoxyribonucleic acid (DNA), found almost exclusively in the cell nucleus, is responsible for the cellular synthetic mechanisms and is quite constant in its concentration per mammalian diploid nucleus (6.2 picograms). Since skeletal muscle tissue is multinucleated, the DNA content is not constant relative to cell numbers. Moreover, nuclear numbers increase in muscle tissue post-natally at a diminished rate with age as "biosynthetic maturity" is attained. It is believed that the amount of sarcoplasmic material that a single nucleus can maintain is limited. Hence, an increase in the number of nuclei would be necessary for sustained muscle growth.

Protein synthesis, nuclear concentration and various cell measurements in skeletal muscle tissue have been extensively studied with laboratory animals. However, the beef animal has received little attention concerning these parameters. Thus, the objective of this study was to examine the DNA, nuclear number and nuclear number per unit volume of the beef animal during growth.

Materials and Methods

Muscle samples were obtained from 18 Hereford and Charolais crossbred steer calves. Six of the steers were slaughtered at each of the following weight groups: 500 lb,

Table 1. DNA concentration, section weight, total section DNA and fiber width in longissimus dorsi muscle of 500, 700 and 900 pound beef steers.

Slaughter Weight Group (Pounds)	DNA Concentration (μg/100mg)	Longissimus Dorsi Section Weight (Kilograms)	Total DNA Per Muscle Section (Grams)	Muscle Fiber Width (Microns)
500	57.567	2.69	1.55	62.9
700	55.662	3.39	1.89	67.9
900	48.534	4.38	2.13	70.2

Table 2. Nuclear number per section, muscle tissue supported per nucleus and fiber width supported per unit of DNA in longissimus dorsi muscle of 500, 700 and 900 pound beef steers.

Slaughter Weight Groups (Pounds)	Nuclear Number Per Muscle Section ($x10^{11}$)	Grams Muscle Tissue Supported Per Nucleus ($x10^{-9}$)	Unit of Fiber Width Supported Per Unit DNA (Microns)
500	2.50	1.10	1.09
700	3.05	1.10	1.22
900	3.43	1.30	1.45

700 lb and 900 lb. Muscle sections were removed from the 7th-13th rib section of the right longissimus dorsi of the freshly slaughtered animals, chilled in ice and prepared for analysis.

DNA was isolated and quantitated by procedures modified from Schneider, 1945 and Burton, 1956. Total grams DNA was determined by multiplying the DNA (µg/ 100mg) by 0.00001 and then by the muscle section weight. Total nuclear number per muscle section was determined by dividing the total grams DNA by 6.2×10^{-12} grams. Grams of tissue supported per nucleus was determined by dividing the muscle section weight by the total nuclear number per section. Fiber width was determined by a microscopic technique previously described.

Results and Discussion

Results in Table 1 show that the DNA concentration (µg/100mg) decreased as the feedlot weight of the animals increased. This decrease in DNA concentration appeared to accelerate with increased weight and age of the cattle.

The longissimus dorsi section weight increased with feedlot weight, as did the total longissimus section DNA content and the average muscle fiber width. However, if the longissimus section weight is expressed as a percentage of the slaughter weight, a definite abatement in weight accretion of the longissimus section can be noted, beginning with the 700 lb slaughter group. This depression in longissimus muscle growth rate was accompanied by lesser increases in both the total DNA per muscle section and muscle fiber width data, all of which may be attributed to the decrease in absoulte DNA concentration.

As may be observed in Table 2, total nuclear number per longissimus section showed an overall increase as slaughter weight and, hence, feedlot time were increased. Yet this increase in nuclear number tended to diminish after the animals had reached 700 lb live weight. This suggests that each cell nucleus had begun to support a greater quantity or volume of muscle tissue as well as a greater portion of the individual muscle fibers at this period of feedlot life. These results would indicate that the longissimus muscle had approached biosynthetic maturity at the 700 lb period and that this degree of maturation was related to the DNA concentration in the muscle.

Literature Cited

Schneider, W. C. 1945. Phosphorous compounds in Animal tissues. I. Extraction and estimation of deoxyribonucleic acid and ribonucleic acid. J. Biol. Chem. 161:293.

Burton, K. 1956. A study of the conditions and mechanisms of the diphenylamine reaction for the colorimetric estimation of deoxyribonucleic acid. Biochem. J. 62:315.

Feed Efficiency and Carcass Characteristics of Ram Lambs Slaughtered at Four Weights

Dale L. Beerwinkle, J.V. Whiteman, L.E. Walters and John E. Fields

Story in Brief

Thirty-six crossbred ram lambs were fed in three pens and three lambs from each group were slaughtered as the average weight in each pen reached 100, 120, 140 and 160 lb. Total feed consumption for each pen and individual weight gains were recorded from 70 to 100 lb and each succeeding 20 lb weight interval. Lambs selected for slaughter were trucked from the Southwest Livestock and Forage Research Station, El Reno, Oklahoma, to the Oklahoma State University Meat Laboratory, slaughtered, and the carcasses evaluated for U.S.D.A. carcass grades and detailed carcass cut-out.

For each successive 20 lb weight interval above 100 lb, about one additional pound of feed was required per lb live weight gain. Average daily gains were similar in each interval except 140 to 160 lb, which were lower. As would be expected, lambs slaughtered at increasing live weights yielded fatter carcasses with less desirable U.S.D.A. yield grades and higher U.S.D.A. quality scores. There was also an improvement in dressing percentage of approximately 2 percent for each 20 lb increase in slaughter weight above 100 lb, up to 140 lb. But, at 160 lb, dressing percentage was about 1 percent less than 140 lb.

When considered as a proportion of carcass weight, the increased fatness of heavier lambs resulted in lower percentages of very closely trimmed cuts. However, due to higher dressing percentages, the fatter, heavier weight lambs were similar in yield of very closely trimmed cuts as a percentage of live weight.

These data indicate that ram lambs may, when feed costs permit, be carried to slaughter weights well in excess of 100 lb. Also, the improved dressing percentage of heavier lambs compensates a great deal for the increased fatness of heavier carcasses. Therefore, differences in yield of closely trimmed retail cuts are small if considered as a proportion of live weight.

Introduction

It has been proposed that feeding lambs to heavier weights before slaughter is one alternative to consider in order to increase the supply of lamb to the consumer. In previous trials (Research Report, 1978), ewe lambs were recognized as inefficient converters when fed to 125 lb slaughter weights and also produced extremely wasty carcasses. Ram lambs, on the other hand, although less efficient converters when carried to 125 lb than at lighter weights, produced quite acceptable carcasses with regard to cutability. These results suggested that, depending on the cost of feed, producers could elect to feed rams to heavier weights. Furthermore, when the yield of closely trimmed cuts was considered in relation to live weight, there were no major differences between sexes and weight groups, despite large differences of degrees of fatness among the carcasses.

In order to further evaluate the efficiency of gain and carcass characteristics of ram lambs fed to weights well beyond 100 lb prior to slaughter, and also to evaluate the effect of improved dressing percentage in heavier lambs, intact male lambs were fed to slaughter weights of 100, 120, 140 and 160 lb. Data from such trials conducted over several seasons should indicate (1) at what slaughter weight does improved dressing percent fail to compensate for the increased fatness of heavier carcasses, and (2) the amount of extra feed required to produce a pound of gain in heavier lambs in various feeding seasons. Moreover, since the ram lambs used in this experiment represent a wide genetic base, there should be some indication if there is sufficient variation to find individuals that can reach heavier weights efficiently and still produce trim carcasses.

Materials and Methods

Ram lambs from the fall 1977 season were placed on feed in January 1978. The lambs were obtained from the eight-month lambing interval project and were progeny of crossbred dams of mixed percentages of Rambouillet, Dorset and Finnsheep that had been mated to Suffolk, Hampshire, Suffolk X Hampshire or Hampshire X Suffolk rams. Each pen was started on feed when 12 lambs could be found weighing between 68 and 72 lb so that the pen average would be 70 lb. Lambs were fed a ration of 45 percent alfalfa, 50 percent milo and 5 percent molasses. When a pen of 12 lambs averaged 100 lb, lambs were sorted by weight into upper, average and lower third weight groups and one lamb from each group chosen at random for slaughter.

The same precedure was followed at pen average weights of 120 and 140 lb. This procedure allowed each lamb an equal chance of being one of the three lambs to be fed from 140 to 160 lb, at which time the remaining lambs were slaughtered. Lambs were shorn before slaughter at 100 lb, and all lambs remaining were shorn when the 120 lb average pen weight was reached. All calculations involving live weight include fleece weight.

Feed efficiency was calculated on total pen feed consumption and gain for each weight interval. Therefore, for each pen, the values involved 12 head for the first interval (70 - 100 lb) and nine, six and three head for the respective, subsequent intervals or in combining the three pens, 36, 27, 18 and nine lambs for each respective interval.

After slaughter, carcasses were chilled for 24 hr at 34°F and then U.S.D.A. quality grade factors were obtained. Carcasses were double wrapped in heavy beef shrouds to prevent undue shinkage prior to cutting, although some dehydration likely occurred especially in the case of trim carcasses with a minimum of external finish. Other carcass factors evaluated included the U.S.D.A. yield grade factors (12th rib fat thickness, actual percent of kidney and pelvic fat, and leg conformation score) and in addition, rib eye area. Dressing percentage was calculated as cold carcass weight divided by the live weight.

The right side was broken into the major wholesale cuts. The leg and loin were separated into bone, lean and fat portions, and the percentage of boneless lean for these cuts calculated as a percentage of carcass and live weight. Two bone-in weights were taken for the rack and loin: (1) a "full cut" weight with all external fat removed; and (2) a "retail cut" weight where the flank portion of the loin and riblets of the rack were removed along with all external fat. The yield of full cut loin and rack was calculated as a percentage of live and carcass weights, and the retail cut rack and loin weights were combined with the boneless leg and shoulder to calculate yield of higher priced retail product in the carcass.

Results and Discussion

Feed conversion

Providing that heavy weight lambs are not discriminated against severely at the market, the most important item for the lamb feeder is feed efficiency. As indicated in Table 1, ram lambs growing from 100 to 120 and from 120 to 140 lb consumed

Table 1. Daily gain and feed efficiency of ram lambs at four weight intervals.

	Weight Interval (lb)			
	70-100	100-120	120-140	140-160
Daily Feed Intake	4.16	4.51	5.31	5.15
A D G[1]	0.72	0.68	0.71	0.60
Pounds feed/pound gain	5.69	6.63	7.47	8.58

[1] Average Daily Gain.

consecutively more feed daily to maintain gains similar to lambs growing from 70 to 100 lb. Therefore, as indicated in the table, it required an extra lb of feed per lb of gain for each 20 lb interval above 100 lb. For example, it took about 8.6 lb of feed for each lb of gain in growth from 140 to 160 lb, or about 3 lb more feed per lb of gain than growth from 70 to 100 lb. The reduction in daily intake in the last interval may be an indication of the increased fatness of these lambs and may have been compounded by the warmer temperatures of late spring and early summer.

Carcass traits

Table 2 shows that as slaughter weight increased, dressing percent increased about 2 percent for each 20 lb live weight, up to 140 lb. Based on previous experience with ewe lambs at 125 lb, which were similar to the 160 lb rams, it was thought that improvement in dressing percent would have been continual with increasing weight. The lower dressing 160 lb lambs may have been the result of chance.

The increase in dressing percent noted was due primarily to an increase in fatness in heavier weight lambs increasing the proportion of carcass components relative to "dress-off" items and probably reducing cooler shrink. As fatter lambs generally have higher quality scores, there was a general increase in U.S.D.A. quality scores in carcasses produced from heavier weight lambs. In general, carcasses from heavier weight lambs had more external finish, more internal fat, and consequently higher numerical U.S.D.A. yield grades. Increased rib eye area was also apparent in heavier carcasses, indicating that muscle growth continues as ram lambs grow to these weights, although fat deposition obviously occurs at a faster rate. Increased loin eye area may serve to make lamb chops appear more attractive in the retail case, offering a meatier appearance especially to infrequent lamb consumers.

As indicated by higher numerical yield grades, carcasses from heavier weight lambs were lower in yield of closely trimmed wholesale and retail cuts as a percentage of carcass weight relative to the 100 lb rams.

In general, as is shown in Table 3, increase in live weight increased the amount of fat trim in the carcass, which is expressed as a decreased percentage of very closely trimmed cuts. Carcasses from 100 lb lambs averaged 3.3 percent more retail cuts than 120 lb lambs, which out yielded the 140 lb group by 2 percent. Carcasses from the 160 lb group yielded only 55 percent of their weight in very closely trimmed retail cuts, or almost 7 percent less than the high cutability 100 lb group.

Table 4 presents the yield of very closely trimmed cuts as a percentage of live weight for each weight group. Due to the higher dressing percentage of lambs from heavier weight groups, the advantage of the 100 lb slaughter group in retail cut yield was greatly reduced. The heaviest lambs (160 lb) yielded the lowest percentage of retail cuts as a percentage live weight, and the lightest lambs (100 lb) yielded the highest. However, the rank of the percent of retail cuts of 120 vs 140 lb groups as a percentage of live weight was reversed from that if yield of very closely trimmed retail cuts was considered as a percentage of carcass weight. With exception of the 160 lb weight group

Table 2. Carcass characteristics of ram lambs slaughtered at four average live weights.

	Average Live Weight (lb)			
	100	120	140	160
Dressing Percentage[a]	46.77	48.79	50.66	49.72
Quality Score[b]	11.9	12.2	13.2	13.0
Fat Thickness[c]	0.18	0.26	0.29	0.36
Percent Kidney/Pelvic Fat	2.8	2.6	4.0	3.7
Rib Eye Area[d]	2.23	2.36	2.70	2.79

[a]Cold carcass weight ÷ Live weight.
[b]Average Choice = 11; High Choice = 12; etc.
[c]12th rib, inches.
[d]Square inches.

Table 3. Yield of very closely trimmed cuts as a percentage of carcass weight.

	Average Slaughter Weight (lb)			
	100	120	140	160
Shoulder[a]	13.86	12.53	12.17	12.10
Leg[a]	17.28	15.18	15.39	14.14
Rack[b]	8.53	8.28	7.85	7.56
Loin[b]	13.47	13.32	12.37	11.56
Retail Cuts[c]	61.93	58.56	56.62	55.04

[a]Boneless, very closely trimmed
[b]Full cut, bone in, very closely trimmed
[c]Retail cut rack and loin, bone in, boneless leg and shoulder, all very closely trimmed

Table 4. Yield of very closely trimmed cuts as a percentage of live weight.

	Average Slaughter Weight (lb)			
	100	120	140	160
Shoulder [a]	6.49	6.09	6.17	6.01
Leg[a]	8.08	7.41	7.79	7.03
Rack[b]	3.99	4.04	3.96	3.76
Loin[b]	6.30	6.49	6.27	5.75
Retail Cuts[c]	28.98	28.55	28.65	27.69

[a]Boneless, very closely trimmed.
[b]Full cut, bone in, very closely trimmed.
[c]Retail cut rack and loin, bone in, boneless leg and shoulder, all very closely trimmed.

being almost a full percent lower, yields of retail cuts as a percentage of live weight were very similar.

The importance of dressing percent has long been recognized by the packer in determining the price of live lambs. In modern meat trade involving the sale of pretrimmed, boxed lamb cuts, cutability in the lamb carcass may be of less importance if lamb tallow has any saleable value, especially relative to the value of offal and other "dress-off" items. This concept is especially applicable in discussion of the yield of retail cuts as a percentage of live weight. Obviously, the ideal situation would be the production of lambs that would yield both a high dressing percent and a high cutability carcass.

Future Plans

The data reported in this article represent the first season of a three season project. With more repetitions across different feeding seasons, it will be seen how the relationship of feed efficiency and increased slaughter weights are affected by season. Moreover, there may be a seasonal effect on composition of gain. Finally, repeated trials should indicate if there are individuals that can attain heavy weights efficiently and produce high cutability carcasses.

Summary Reports

MEAT and CARCASS EVALUATION

Estimation of Muscle Fiber Area in Calf Muscles by Coulter Counter and Photo Micrographic Techniques

J. J. Guenther, R. D. Morrison, K. K. Novotny and Jane Bartlett

Muscle fiber area or radial growth is an important parameter in assessing the influence of various genetic and treatment effects on muscle growth. Hence, procedures were developed to determine muscle fiber area by an automated Coulter Counter and a photomicrographic projection technique. These procedures were used to determine the fiber area of the Longissimus dorsi, Sartorius, Semitendinosus and Triceps brachii muscles taken from six, 15-day-old dairy calves.

Results are summarized in Table 1. No statistical significant differences between sides were noted in muscle fiber area by either technique. However, fiber area determined by the photomicrographic projection technique was significantly larger than that estimated by the Coulter Counter procedure. The average fiber area obtained by the Coulter Counter was 394 microns squared, while that by the photomicrographic procedure was 821 microns squared for the four test muscles.

Studies suggested that the unfixed muscle fibers possessed electrical conductivity which interfered with the resistance change in the apperture of the coulter cell. This would reduce the pulse height and result in a lower value for the fiber area measurements determined by the Coulter Counter method. Nevertheless, the standard error of the muscle fiber areas determined by the Coulter Counter was consistently smaller than that obtained with the photomicrographic projection technique.

Table 1. Estimation of muscle fiber area in four calf muscles by Coulter Counter and Photomicrographic techniques.

Estimation Technique	Muscle			
	Longissimus dorsi	Sartorius	Semitendinosus	Triceps brachii
Coulter Counter	284[1,2]	447	405	440
Photomicrographic	635	951	854	844

[1] Microns squared.
[2] Average of 216 values.

Count as a Predictor of Muscle Mass in Yearling Beef Bulls

G. R. Rider, L. E. Walters, R. R. Frahm, E. E. Kohnke and B. W. Lambert

Earlier work at this station has shown the estimation of fat-free lean in yearling beef bulls by the ^{40}K whole-body counting techniques to be useful when used in conjunction with other performance data in selecting yearling bulls that have superior genotypes for rapid growth of muscle. The whole-body counter determines the quantity of electricity resulting from the emission of gamma rays from a radioactive isotope of potassium, ^{40}K. This isotope occurs naturally in the live animal and emits a weak and harmless gamma ray.

The basic principal of this evaluation technique is that a large part of total body potassium is found in the muscle and a constant proportion of this potassium is radioactive. It follows that differences in ^{40}K count among animals should estimate differences in the quantity of total lean among these animals.

The earlier research referred to was conducted using animals that were quite uniform in weight. Later research emphasized the need to identify sources of variation in the data where differences in the live weight of test animals occured because the counter was found to be less efficient in estimating whole-body potassium in heavier cattle.

Researchers using non-living masses of different materials have found that counter efficiency is reduced in larger masses by the phenomena called background depression and self-absorption. Through the creation of "phantoms" (non-living masses), approximating the dimensions and density of bulls weighing 900, 1000, 1100, 1200 and 1300 lb, and through subsequent research on the reduction of counter efficiency due to background depression by these weights, an adjustment system has been developed. This system is believed to enable one to compare the fat-free lean estimate by ^{40}K bulls of different weights with more confidence than has been possible in the past.

The purpose of this study was to evaluate net ^{40}K count when adjusted for background depression and self-absorption as a predictor of total lean in yearling beef bulls ranging in weight from 900 to 1300 lb.

Twenty-five Hereford and 22 Angus yearling bulls were fed under drylot conditions, not unlike many bull test stations, to randomly pre-assigned ^{40}K count weights. The Hereford bulls were obtained from the Animal Science Experimental Beef Herd and the Angus bulls were produced on a purebred ranch in Oklahoma. The younger Hereford calves averaged 460 lb going on feed while the older Angus calves averaged 686 lb.

Some bulls were slaughtered earlier than planned because of their inability to continue acceptable gains at heavier weights. The ration contained 27.8 percent steam rolled corn, 29.5 percent steam rolled oats, 4.3 percent dehydrated alfalfa pellets, 18.2 percent cottonseed hulls, 5.4 percent molasses and 14.8 percent soybean meal.

As the bulls reached the pre-determined count weight, they were trucked less than one mile to the O.S.U. Live Animal Evaluation Center and held off feed and water for

24 hr prior to the first of two counts. During this period, each bull was thoroughly washed using a low potassium soap in order to remove any foreign material that might alter the net ^{40}K count.

The bulls were individually counted in random order twice during the count day. A background count of the empty chamber was taken just prior to placing an animal in the chamber and again immediately after removal. The net ^{40}K count for the animal was the difference between the count with the animal in the counter and the average of two background counts.

Following the counting, the animals were trucked to the O.S.U. Meat Laboratory and slaughtered. After chilling in a 34°F cooler, the right half of each carcass was physically separated into very closely trimmed lean, fat and bone, and individual weights were recorded. The loin, rib, round and chuck were trimmed of all visible fat, the "thick" muscle systems were removed from the bone, and seam fat in excess of .1 inch was removed. Thinner muscle systems from these four cuts, with fat more difficult to remove, were later blended with similar "thin" lean from the minor wholesale cuts for chemical fat analysis.

The shank, brisket, plate and flank were also very closely trimmed of fat, the lean was removed from the bone and all fat in excess of .1 inch was removed. This boneless, closely trimmed lean from these cuts were blended with similar lean from the four major wholesale cuts, ground and sampled for chemical fat analysis. Total carcass lean was determined to be total "thick" closely trimmed boneless lean + (total "thin" trimmed lean - chemical fat) x 2. Chemical fat was determined by the modified Babcock fat test.

Since the analysis of the data has not been completed, only preliminary observations are presented. Count weight for the bulls ranged from 970 to 1264 lb with a mean count weight of 1114 lb and a standard deviation of 88 pounds. Table 1 presents a grouping of the cattle into four uniform weight groups along with average values for some preliminary observations.

The lean content in Group I and II bulls was quite similar as was the increase in amount of lean between Groups I and II (19.8 lb) and Groups II and III (22.8 lb). Percentage lean of count weights was also quite similar for Groups I, II and III with 34.6, 34.0 and 34.1 percent, respectively. However, from a body composition standpoint there appeared to be a reduction in lean production relative to other body components in the Group IV bulls. This is expected since generally, among cattle of this weight fed in the drylot, as body weight increases, so does the proportion of fat as a component of the gain.

Table 1. Population description and some preliminary observations.

Weight Groups	I	II	III	IV
Observations				
Count Wt. Range (lb)	**970-1043**	**1044-1117**	**1118-1191**	**1192-1264**
Number of bulls	13	10	12	12
Ave. Total Carcasses Lean (lb)	348.4	368.2	391.0	402.4
Ave. Total Carcass Lean (lb) (as % Count Wt)	34.6	34.0	34.1	31.6
Correlation Coefficient (^{40}K predicted vs actual carcass lean)	.88	.87	.70	.88

One means of evaluating the usefulness of adjusted ^{40}K count as a predictor of total carcass lean is to determine correlation coefficients between that amount of lean predicted from adjusted net ^{40}K count and the amount of carcass lean as determined from slaughter, physical separation and chemical analysis methods. The higher the correlation between these two variables, the more effective adjusted net ^{40}K count will be in detecting differences in the lean content of animals across weight groups.

Correlation coefficients of .88, .87, .70 and .88 for Groups I, II, III and IV, respectively, indicate a fairly strong correlation between the predicted and actual lb of carcass lean within each weight group. The pooled within weight group correlation was .83 which means that, on the average, 68.7 percent (correlation coefficient squared) of the variation in the weight of carcass lean is accounted for by the adjusted net ^{40}K count. These correlations indicate that ^{40}K count adjusted for "background depression" and "self-absorption" may well prove useful as a predictor of carcass lean in yearling beef bulls over a range of live weights. It should be pointed out that considerable variation in correlation coefficients is normally expected when as few as 10 to 13 observations are available. A complete analysis of the data will be accomplished in the near future.

DAIRY PRODUCTS

Chemical Test for Detection of Wheat Pasture Flavor Component in Raw Milk

H. S. Kim, S. E. Gilliland and R. L. Von Gunten

An undesirable flavor characterized as "fishy"which occurs in milk from cows which have grazed on wheat pasture has been a problem in wheat growing areas. Even though the component that causes fishy flavor in milk was identified as trimethylamine, detection of low concentration of trimethylamine in field conditions remains a problem in dairy industry.

A rapid and easy chemical test for detection of trimethylamine in raw milk has been established by adding formaldehyde and sodium hydroxide to a sample of milk to release volatile amines. The formaldehyde serves as a complexing agent to retain ammonia, primary and secondary amines so that they will not appear in the volatile fraction. The volatile components which contains any trimethylamine are then checked with a pH indicator.

Twenty ml of a raw milk sample was placed into a 2.5 x 15 cm test tube. One ml of formaldehyde (37 percent formaldehyde in 10 percent methanol) and one ml of 5 percent aqueous sodium hydroxide were added to the milk. The tube was then stoppered with a rubber stopper fitted with two glass tubes (0.2 cm ID). One tube (5 cm long) contained a piece of white yarn (100% Virgin Orlon Acrylic fiber) saturated with bromocresol green (BCG). This was accomplished by dipping the yarn in the indicator (0.1 percent BCG) and drying it prior to placing it in the glass tube. This tube was inserted so that it extended above the stopper. The other tube was inserted through the stopper so that it reached the bottom of the test tube. The other end of the second glass tube was connected to an aquarium air pump via a rubber tube. Air was bubbled through the milk sample (6 ml/min). The height of color change (from orange to green) on the yarn was measured at one minute intervals during a six minute time period. The test tube was submersed in a 28 C waterbath during the test.

By this chemical test, the intensity of fishiness in milk from cows which had consumed wheat pasture was easily shown by the height of green color. Raw milk samples which exhibited more than a 1.0 cm height of green color change by this test were identified by a trained sensory test panel as having a very slight fishy flavor. Using a standard curve prepared with TMA standards in raw milk, such samples were found to contain approximately 2 ppm TMA. This concentration of TMA in raw milk could be estimated within three minutes by using the chemical test. Thus, the chemical test described herein could be used as a rapid detection method for TMA at the farm bulk milk pick up area.

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