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Cow-Calf and Stocker

Evaluation of a Stress Index for the Study of Shipping Fever in Stocker Cattle

R.P. Wettemann, F.P. Horn, T.W. Beck and J.L. Drew

Story in Brief

A method was developed as a possible index to evaluate adrenal function of steers in response to the stress imposed at different times during weaning and transportation to wheat pasture or the feedlot. This test involves determining the maximum corticoid secretion following treatment with ACTH (adrenocorticotropic hormone). Since adrenal secretion of corticoids is normally controlled by ACTH produced by the animal's pituitary, the response obtained in this test indicates the ability of the adrenal to secrete corticoids in response to stress. Cannulae were inserted in the jugular veins to reduce the stress associated with frequent blood sampling. Our results demonstrate that steers can be cannulated in the morning and adrenal function can be evaluated in the afternoon of the same day. Plasma corticoids are at maximum concentrations between one and two hours after ACTH treatment.

Introduction

Each year hundreds of thousands of calves are transported from farms in the humid southeastern U.S. to the sub-humid and semi-arid grain producing areas of the southern great plains. While these are usually referred to as "feeder calves," such calves would more appropriately be called "stocker calves" since many actually spend several months grazing winter small grains pasture after arrival in the plains areas. Regardless of whether calves are shipped directly from the farm to the feedlot or whether they pass through a stocker phase, the process of weaning, assembling and transporting these calves imposes a tremendous stress which results in death losses approaching three to five percent. Thus, it would appear that the development of a stress index would aid in evaluating which phases of the process are most detrimental to animal health.

In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

The adrenal glands, through the release of the adrenal hormones (corticoids), play an important role in adaptation of an animal to many kinds of stress. The secretion of corticoids by the adrenal gland is controlled by adrenocorticotropic hormone (ACTH) secreted by the anterior pituitary gland. Thus, changes in the secretion of corticoids by the adrenal gland in response to the ACTH released by the pituitary gland should be related to the ability of the animal to adapt to stress.

Concentrations of corticoids in the blood vary greatly both between different animals at the same time or in the same animal at different times. For this reason, collecting a single blood sample from a group of animals and measuring concentrations of corticoids gives little useful information about adrenal function. There is a clinical test used in human medicine that does give a fairly accurate estimate of adrenal function. This test involves the measurement of blood concentrations of corticoids following an injection of enough ACTH to stimulate the adrenal to the maximum. The assumption is that the greater the response obtained to maximum stimulation, the greater the capacity of the adrenal glands to produce corticoids to help resist stress.

The purpose of this experiment was to evaluate this technique for measuring adrenal function in cattle.

Materials and Methods

Ten steers each weighing about 600 pounds were used in this experiment. The steers were maintained in individual slotted-floor pens and fed approximately 12 pounds of ground alfalfa hay daily. On the first day, indwelling cannulae were inserted into the jugular veins of five steers selected at random (Group 1) between 8 and 10 a.m. On day two, cannulae were inserted into the other five steers (Group 2) between 8 and 10 a.m. Cannulae were used to permit the collecting of frequent blood samples without disturbing the animals. The restraint necessary for bleeding by jugular puncture may release ACTH from the steers pituitary, which would alter plasma corticoids. At 1 p.m. on day two, all ten steers were infused with 200 I.U. of ACTH via cannulae. Blood plasma samples were collected one hour before and at selected intervals until eight hours after ACTH treatment. On days four and five the above procedure was repeated, and the groups of five steers were switched between the two cannulation times so that Group 2 was cannulated on the day preceding ACTH and Group 1 was cannulated on the day of ACTH. Total plasma corticoids were measured in the samples by a radioisotope protein binding assay.

Results and Discussion

Plasma corticoid concentrations increased rapidly after ACTH infusion, reaching a maximum between one and two hours after treatment (Figure 1).

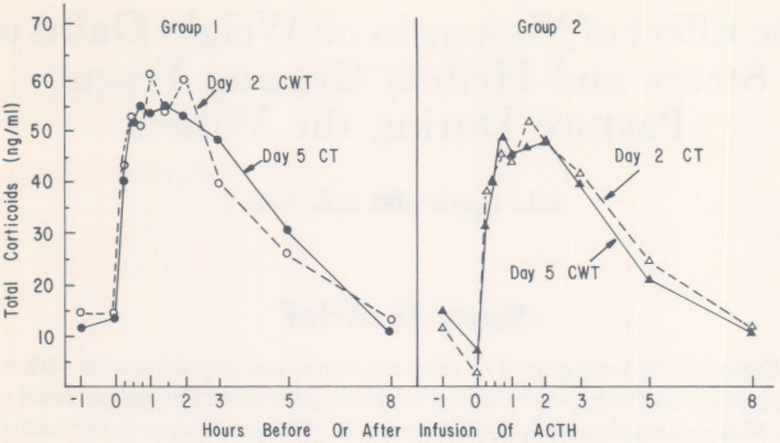

Figure 1. Total plasma corticoids in two groups of five steers infused with ACTH either on the day of cannulation (CT) or the day after cannulation (CWT).

Therefore, this would be the optimum time to sample steers to determine maximum adrenal response to ACTH.

Average plasma corticoids were greater after ACTH treatment in Group 1 than in Group 2 at both times that the animals were treated. This indicates that evaluation of the same steers before and after a treatment is helpful to reduce some of the variability in plasma corticoid concentrations.

It was anticipated that the restraint of animals and the stress associated with cannulation might influence the evaluation of adrenal function if both were done on the same day. However, time of cannulation did not influence plasma corticoids after ACTH treatment. Within a group of steers, plasma corticoid concentrations were similar whether the animals were cannulated approximately three or 27 hours before treatment. Therefore, these data demonstrate that it is possible to cannulate steers in the morning and evaluate adrenal functions in the afternoon of the same day. Using this procedure, it should be possible to develop a stress index based on an evaluation of the adrenal function of calves at different stages of the process of transportation from site of weaning to wheat pasture or feedlot.

The Effect of Monensin on Weight Gains of Steers and Heifers Grazing Fescue Pasture During the Winter

K.L. Apple and D.R. Gill

Story in Brief

Eighty cattle were grazed on fescue pastures and supplemented with two pounds of ground milo pellets with or without monensin (200 mg. per head per day). Monensin increased gains 32.5 pounds (23.2 percent) over the controls during the 112-day trial. The increase in weight gain due to monensin was quite large, especially since the extreme cold weather (1976-1977) limited forage production. The response to monensin was much larger during the last 56 days of the test where forage quality was probably at its lowest.

Introduction

Monensin has been cleared and used to improve feed efficiency in feedlot cattle. Usually feed intake is reduced and gains not effected when monensin is added to feedlot diets. Monensin appears to improve energetic efficiency within the rumen of cattle. Other data in this publication (page 42) suggest that monensin may have a protein sparing effect.

When monensin is fed to cattle grazing forage, the improvement in efficiency shows a different pattern than in feedlot cattle, in that the cattle may not reduce forage intake, but usually increase their rate of gain.

Research suggests a six to 11 percent improvement in feed efficiency for feedlot cattle and possibly two or three times this improvement for stocker cattle. This occurs possibly because most of the energy that stocker cattle consume is used to maintain the animal and less is used for weight gain. Thus, a small improvement in energetic efficiency in the rumen or digestive tract could translate into a much larger increase in rate of gain.

The potential for decreasing the costs of stocker gains through the feeding of monensin is very large, especially since this compound does not reduce the response to implants used in stocker production on forage.

Materials and Methods

Fifty crossbred steers and thirty crossbred heifers (25 steers, 15 heifers per pasture) were used in a trial from October 20, 1976, to February 8, 1977 (112 days). Cattle were weighed after an overnight stand without feed and water at the start and at each 28-day weigh period. Routine processing was done at the start of the trial, and all cattle were implanted with 36 mg. of Ralgro® at this time. Pastures consisted of fescue, dry bermuda, and limited amounts of white clovers. Fescue growth was hampered by below average temperatures during the last 45 days of the trial. Two adjacent 40 acre fescue pastures were stocked at one animal per acre throughout the trial. Cattle groups were rotated every two weeks to minimize pasture effect.

Both the control and treatment cattle received a daily supplement of two pounds of pelleted ground milo per head. The treatment pellet contained 100 mg. monensin per pound, providing a daily level of 200 milligrams. Supplemental bermuda grass hay was fed in equal amounts to both groups during the last 47 days of the trial. Hay consumption averaged 9.41 pounds per head per day during this period.

Results and Discussion

Cattle receiving the monensin pellet gained 32.5 lb (23.2 percent) more than controls. This difference was significant across steers and heifers ($P<.01$). Period weights are shown in Figures 1 and 2 for heifers and steers, respectively.

Heifers fed monensin on the average gained 33 pounds (25.8 percent) more than the controls, while steers gained 32.2 pounds (21.9 percent) more

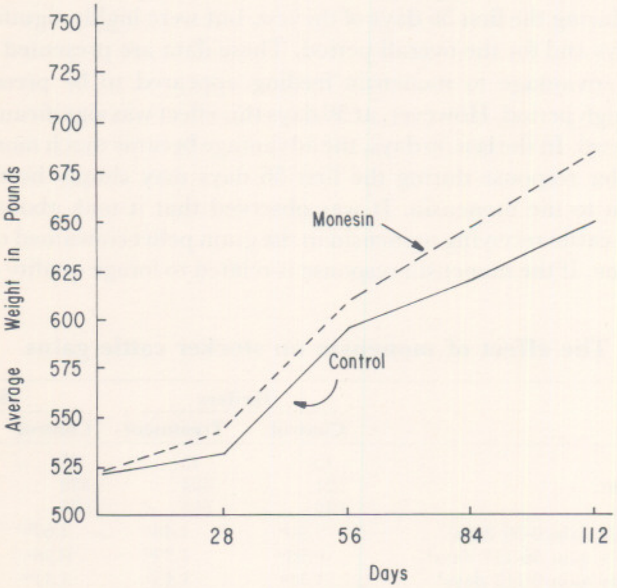

Figure 1. Monensin field trial crossbred heifers Idabel, OK 1976-1977.

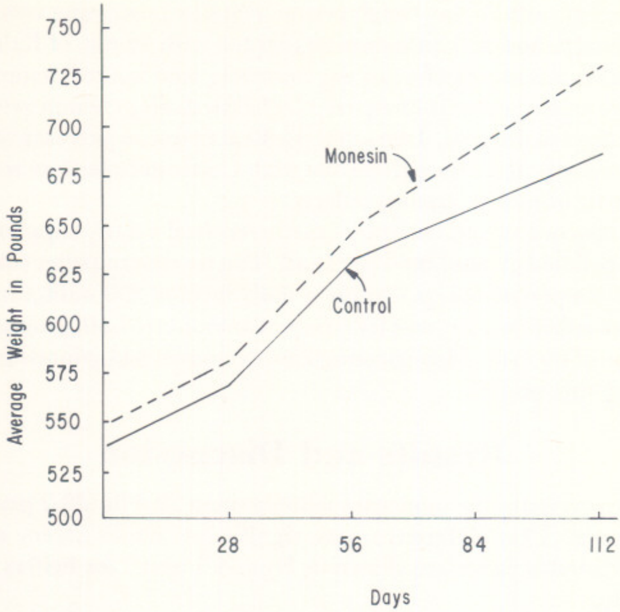

Figure 2. Monensin field trial crossbred steers Idabel, OK 1976-1977.

than their controls. Weight gains within sex groups were not statistically different during the first 56 days of the test, but were highly significant for the last 56 days and for the overall period. These data are presented in Table 1.

The advantage to monensin feeding appeared to be present at each 28-day weigh period. However, at 56 days this effect was significant only at the ($P<.10$) level. In the last 56 days, the advantage became much more apparent. The smaller response during the first 56 days may simply be the result of adaptation to the monensin. It was observed that it took about two weeks before the cattle receiving monensin in the grain pellet consumed the pellets in a short time. If the monensin response is related to forage quality or a protein

Table 1. The effect of monensin on stocker cattle gains

	Heifers		Steers	
	Control	Treatment	Control	Treatment
Number	15	15	25	25
Initial weight	521	524	538	549
Final weight	649	685	685	729
Average daily gain 0-56 days[1]	1.30[a]	1.48[a]	1.67[b]	1.74[b]
Average daily gain 56-112 days[1]	0.98[a]	1.39[b]	0.96[a]	1.47[b]
Average daily gain 0-112 days[1]	1.14[a]	1.43[b]	1.31[b]	1.60[c]

[1]Numbers with different superscripts differ significantly ($P<.05$).

sparing effect, the forage quality was much higher during the first 56 days than in the last. Bermuda hay made up a large part of the total dry matter intake during the last 47 days of the trial. Daily intake of protein should have been very adequate in the early part of the test, but would have declined to marginal levels during the last 56 days due to the weather related failure to grow green forage.

The overall response to providing 200 mg. of monensin to cattle grazing fescue, later supplemented with bermuda hay, was excellent in a 112-day test conducted in southeast Oklahoma. Some question remains as to the response on high vs. low quality forage, but it appears that the response was larger as the forage quality was lowered.

Monensin for Range Beef Cows

R.P. Lemenager, F.N. Owens, E.L. Ferrell, D.B. Belcher, K.S. Lusby and R. Totusek

Story in Brief

Seventy-two mature Hereford cows were employed to evaluate the supplemental value of monensin for beef cows grazing low quality dry winter range grass. The two treatments were 30 percent natural crude protein supplements with zero or 200 mg of monensin/cow/day.

Cow weight change during the dry grass portion of the trial was not affected by monensin, although weight gain of cows grazing green grass tended to be higher when monensin was fed.

Monensin supplemented cows did not differ from control cows in pounds of milk produced, percent milk solids, butterfat or solids-not-fat. However, addition of monensin to the supplement decreased ruminal molar percent acetate and butyrate, and increased ruminal propionate.

This experiment indicates that the addition of monensin to range supplements: (1) does not affect cow weight change during the dry winter grass portion of the year, but it may increase cow weight grain when green grass appears in the spring; (2) decreased grazing time about 15 percent during the dry winter grass portion of the trial; (3) increases propionate and decrease

acetate and butyrate, and (4) does not alter milk production or milk composition.

Introduction

Monensin (trade name Rumensin), a biologically active compound produced by a strain of *Streptomyces cinnamonensis,* has been shown to increase the molar proportion of rumen propionate and decrease rumen acetate. The product is now used widely with feedlot cattle and has been shown to increase feed efficiency of cattle fed high concentrate rations.

Cattle on lush forage have shown improved gains and feed efficiency when monensin was fed. Monensin has not been shown to have deleterious effects on lactation or early calf performance when cows were fed hay.

The purpose of this study was to further evaluate the addition of monensin to supplements for lactating cows.

Procedure

A 152-day winter trial was conducted in central Oklahoma on native tallgrass range with climax vegetation of little bluestem, big bluestem, Indian grass, and switch grass.

Seventy-two mature lactating Hereford cows were randomly allotted, after blocking by weight and calving date, to two treatments with two replications per treatment. Cows were placed on four pastures, and rotated among pastures at 14 day intervals to minimize pasture and location effects. The two treatments were 30 percent natural crude protein supplement with zero or 200 mg of monensin added per cow per day. Table 1 shows the ingredient make-up of the supplement. The supplements were self-fed at a rate of 3.2 lb/cow/day with salt added to limit intake.

Cows calved from October 11 to December 3 with a mean calving date of November 1 and November 2 for the control and monensin supplement, respectively.

Table 1. Ingredient makeup of protein supplement

Item	% in Supplement
Corn	22.77
Soybean meal (44%)	58.25
Ground alfalfa hay	10.00
Molasses	5.00
Monosodium phosphate	2.50
Dicalcium phosphate	.75
Sodium sulfate	.68
Trace mineral mix	.05
Vit. A	22,000 IU/kg

Four 24-hour pasture observations were conducted to estimate grazing time and frequency of supplement intake. Grazing time was estimated by observing each cow every 15 minutes, and recording whether she was grazing or not grazing. The supplement feeder was under continuous observation, and frequency and duration of supplement intake were recorded. Each of the treatment replications were observed twice during the winter supplementation period. Immediately following the pasture observations, rumen samples were taken from 10 randomly selected cows per treatment to determine the effect of monensin on molar porportions of acetate, propionate, and butyrate.

Four milk productions were taken by the calf weigh-suckle-weigh technique on all cows on days 62, 83, 110, and 150 of the trial to determine the effect of monensin on milk production. Two milk compositions were taken on all cows on days 95 and 139 of the trial to determine the effect of monensin on butterfat. Cows were injected with eight cc of Sparine (a tranquilizer) IM approximately 45 minutes prior to milking, and injected with one cc of oxytocin in the jugular vein immediately preceeding milking. Cows were milked out with the use of a milking machine, and samples were taken for butterfat analysis. Samples on day 139 were analyzed for butterfat, milk solids, and solids-not-fat.

Results and Discussion

Cow performance results are shown in Table 2. Average daily supplement intakes were approximately equal on the two treatments. Weight change of cows was similar during the dry grass portion of the trial, but cows fed monensin appeared to gain faster when green grass appeared in the spring.

Grazing observation results are shown in Table 3. Cows on the monensin supplement tended to graze about 15 percent less than control supplemented cows during the first three grazing observations. After green grass appeared (grazing observation 4) cows on the monensin supplement grazed about 6 percent more than control supplemented cows. This could partially explain

Table 2. Cow performance

	Monensin, mg/cow/day	
Item	**0**	**200**
Cows, number	36	36
Ave. daily supplement, lb.	3.3	3.2
Ave. daily salt, lb.	1.27	1.13
Ave. calving date	Nov 1	Nov 2
Initial cow wt., lb.	942.7	940.3
Total cow weight change, lb.	-13.2	+1.8
Dry grass weight change, lb.	-90.2	-97.3
Green grass weight change, lb.	+77.0	+99.1

Table 3. Pasture observations (cows)

Item	Monensin, mg/cow/day	
	0	200
Grazing observation 1		
Grazing time, %	30.5[1]	28.4[2]
Freq. of supp. intake, times/day	5.5	5.2
Duration of supp. intake, min.	7.6	10.3
Grazing observation 2		
Grazing time, %	36.2[1]	26.0[2]
Freq. of supp. intake, times/day	5.2	5.2
Duration of supp. intake, min.	11.1	7.8
Grazing observation 3		
Grazing time, %	29.8	28.0
Freq. of supp. intake, times/day	4.2	3.3
Duration supp. intake, min.	4.6	7.5
Grazing observation 4		
Grazing time, %	41.0	43.3
Freq. of supp. intake, times/day	5.1	4.7
Duration of supp. intake, min.	6.0	6.5

[1,2]Values with different superscripts are significantly different ($P < .1$).

the increased weight gain of monensin supplemented cows after green grass appeared.

Cows on both supplements tended to go to the supplement feeder with an equal frequency during the grazing observations. The overall mean for control cows was 5.0 time/day and for monensin fed cows was 4.6 times/day. Cows on both supplements tended to consume supplement an average of 37.0 minutes per day.

Total and molar percentages of volatile fatty acids are shown in Table 4. The addition of monensin significantly decreased acetate and butyrate and significantly increased propionate. This suggests an increased efficiency and may partially explain the 15 percent reduction in grazing time without adversely affecting cow performance or lactation.

Table 4. Total and molar percentage Volatile fatty acids in rumen fluid of cows

Item	Monensin, mg/cow/day	
	0	200
Acetate, molar %	78.1[1]	68.9[2]
Propionate, molar %	16.5[2]	26.6[1]
Butyrate, molar %	5.3[1]	4.4[2]
Total, mM/l	39.2	41.7

[1,2]Values with different superscripts are significantly different ($P < .01$).

Table 5. Milk parameters

Item	Monensin, mg/cow/day	
	0	200
Milk production, lb[1]	8.8	8.8
Milk production, lb[2]	13.6	13.2
Butterfat, %	3.2	3.1
Milk solids, %	12.8	12.9
Solids-not-fat, %	9.6	9.8

[1]Mean of four 24 hour milk productions by calf weight-suckle-weight technique.
[2]Mean of milk production by milking machine technique.

Milk production and milk composition results are shown in Table 5. Milk production was not affected by the addition of monensin when estimated by either the calf weigh-suckle-weigh technique or the complete milk out with milking machine. Estimated milk production is somewhat lower by the calf weigh-suckle-weigh technique, but it is believed to be a more accurate estimate of what calves are actually consuming than is the milking machine estimate. Butterfat, solids, and solids-not-fat were not affected by the addition of monensin to the range supplement.

Calf performance from cows fed monensin is shown in Table 6. Total calf gain was significantly increased in calves reared by cows fed the monensin supplement. Calves reared by monensin fed cows gained 0.08 lb./day faster than calves reared by cows fed the control supplement over the entire trial. The dry grass and green grass gain of calves was not significantly affected by the addition of monensin; however, calves reared by monensin fed cows tended to gain faster in both phases of the trial.

During the first grazing observation it was noted that some calves from each treatment were consuming supplement; therefore, in second and subsequent grazing observations calves were also observed. Pasture observation results are shown in Table 7. In grazing observation two, 17 out of 17 calves were consuming control supplement, while 16 out of 18 were consuming monensin supplement. In grazing observation three, 17 out of 17 calves were consuming control supplement and 16 out of 18 were consuming monensin supplement, respectively. In grazing observation four, nine out of 18, and 16

Table 6. Calf performance from cows fed monensin

Item	Monensin, mb/cow/day	
	0	200
Initial calf wt., lb.	234.3	234.5
Total calf gain, lb.	197.8[2]	210.5[1]
Dry grass gain, lb.	115.3	123.1
Green grass gain, lb.	82.5[4]	87.4[3]

[1,2]Values with different superscripts are significantly different ($P < .05$).
[3,4]Values with different superscripts are significantly different ($P < .10$).

Table 7. Pasture observations (calves)

Item	Monensin, mg/cow/day	
	0	200
Grazing observation 2		
No. of calves eating supplement	17	16
Freq. of supp. intake, times/day	3.5	3.0
Duration of supp. intake, min.	3.6	3.1
Grazing observation 3		
No. of calves eating supplement	17	13
Freq. of supp. intake, times/day	2.6	1.8
Duration of supp. intake, min.	4.0	3.4
Grazing observation 4		
No. of calves eating supplement	9	16
Freq. of supp. intake, times/day	1.3	2.6
Duration of supp. intake, min.	3.0	3.4

out of 18 were eating control and monensin supplements, respectively. Calves consuming both supplements went to the supplement feeder an average of 2.5 times/day. Calves consuming supplement ate an average of 8.6 and 8.1 minutes/day on the control and monensin supplements, respectively.

Increased calf gains during the trial can be partially, if not totally, explained by calves consuming supplement. This seems likely since milk production and milk composition were not altered by the addition of monensin.

Monensin in this trial appears to have increased the efficiency of forage utilization by decreasing grazing time 15 percent without adversely affecting cow performance or lactation. Calf gains were increased 6.4 percent, presumably by altering efficiency of utilization of milk and/or forage.

Effects of Two Milk Levels on Performance of Two Calf Types

K.C. Barnes, L.D. Ridenour, M.B. Gould, K.S. Lusby and R. Totusek

Story in Brief

The effect of two levels of milk intake on the performance of calves of two growth potentials on range was determined. This was accomplished by breeding Hereford x Holstein (crossbred) cows to Charolais x Angus bulls and Holstein cows to Charolais bulls, followed by reciprocal cross-fostering whereby calves of each breed combination were exposed to a medium (crossbred) or high (Holstein) level of milk. In this study, a smaller than desired difference between the medium and high levels of milk production was observed due to a lower than normal production of milk by the Holstein cows. This reduced milk level of the Holsteins was attributed to the accumulative effects of six consecutive years of production under Oklahoma range conditions.

The high level of milk (23-25 lb/day, produced by Holsteins) resulted in an additional 75 pounds of weaning weight in Charolais-Angus x Hereford-Holstein (crossbred x crossbred) calves. Increasing the level of milk comsumption from 19.1 to 25.1 lb./day resulted in a reduction in apparent efficiency of conversion of milk to calf gain of 17 percent in crossbred x crossbred calves. Charolais x Holstein calves on the high level of milk consumed only 1.8 lb more milk per day than on the medium level of milk. Among Charolais x Holstein calves the high level of milk resulted in an additional 26 pounds of weaning weight, although 15 pounds of additional milk was required for each pound of additional gain.

Relative forage intake was reduced 49 percent in Charolais x Holstein calves on the high level of milk, but was not influenced by level of milk intake in crossbred x crossbred calves.

Introduction

Selection for increased calf weaning weight usually results in an automatic selection for higher milk production in cows due to the strong positive relationship between milk production level and calf weaning weight. In recent years, there has been considerable interest in the infusion of dairy breeding into beef herds as a means of increasing the milk yield of cows and intensifying the cow-calf enterprise.

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Since 1969 an intensive research effort at the Oklahoma Agricultural Experiment Station has been directed toward defining the relationships between milk production levels, resource (land and supplemental feed) requirements, reproduction of cows, and calf performance of Hereford, Hereford x Holstein, and Holstein cows managed under tallgrass range conditions.

Increasing the milk production level in cows resulted in distinct increases in calf weaning weights. However, the effects of increased milk consumption on calf performance were not clear since level of milk production was confounded by genetic differences for growth rate in dams of the calves.

Wyatt *et al.* (1976) reported results of reciprocal cross-fostering of calves of Holstein and Hereford cows, resulting in calves of two growth potentials, raised on two milk levels (low and high). This report will present results of calves raised on medium and high milk levels.

Materials and Methods

Thirty-one Hereford x Holstein (crossbred) and Holstein cows were used to study the effects of two levels of milk intake on calves of two growth potentials. A system was devised whereby calves of similar growth potential could be exposed to a medium (crossbred) and high (Holstein) level of milk consumption. The Hereford x Holstein cows were bred to Charolais x Angus bulls, and Holstein cows bred to Charolais bulls followed by reciprocal crossfostering of about one-half of the calves at birth. Thus, within each calf breed (crossbred x crossbred and Charolais x Holstein) one group was the recipient of a medium level of milk (19 to 21 lb/day) while another group received a high level of milk (23-25 lb./day).

All cows were seven-year-olds producing their sixth calf. Cows were maintained on tallgrass native range, and calved during December, January, and February.

Cows received a post-calving winter supplement level considered adequate for their size and milk production level, based on the results of earlier work at this station. Crossbred and Holstein cows were fed 5.2 and 7.6 pounds per day, respectively, of a 28 percent all-natural crude protein supplement. These supplement levels were calculated to allow a 20 percent winter weight loss including calving.

Parturition was induced in some cows by the administration of 40 mg. dexamethazone (Azium) within 10 days of the expected calving date to facilitate scheduling of the cross-fostering program.

Forage intake of calves was estimated in August 1976, while calves were on lush native pasture. Relative forage intake by calves was estimated by use of an external indicator technique employing chromic oxide as the indicator.

Results and Discussion

Performance of cows is summarized in Table 1. Supplement was fed at the rate of 5.2 and 7.6 pounds per day to the crossbred and Holstein cows, respectively. Winter weight losses were similar for both breeds, with cows raising the larger Charolais x Holstein calves tending to lose more weight. Since cross-fostering was conducted on the first calves born, calves raised on their natural dams (crossbred x crossbred on crossbred cows and Charolais x Holstein calves on Holstein cows) were generally born from two to four weeks after the cross-fostered calves.

Calf performance is summarized in Table 2. Crossbred x crossbred calves consumed 19.1 and 25.1 pounds of milk daily at the medium and high milk levels, while Charolais x Holstein calves consumed 21.0 and 22.8 pounds of milk daily at the medium and high levels, respectively. In previous years, the Holstein cows had averaged from 27-29 pounds of milk per day over the 240-day period. Apparently, the cummulative effects of six consecutive lactations under range conditions reduced the milking ability of the Holsteins. Lower milk production was especially noticeable among the Holsteins nursing Charolais x Holstein calves. This may be partially explained by the 32-day later average calving date of the Charolais x Holstein calves. Later calving

Table 1. Performance of cows

Breed of dam	Hereford x Holstein		Holstein	
Breed of calf	Crossbred x crossbred	Charolais x Holstein	Crossbred x crossbred	Charolais x Holstein
Daily winter supplement post-calving, lb.	5.2	5.2	7.6	7.6
Weight, Fall 1975, lb.	1148	1196	1344	1292
Weight, Spring 1976, lb.	963	955	1106	1051
Winter weight change, lb.	-185	-241	-283	-241
Winter weight loss, %	16.1	20.2	17.7	18.7
Calving date	1-21-75	1-5-75	1-4-75	2-6-75

Table 2. Performance of calves

Breed of calf	Crossbred x cross bred		Charolais x Holstein	
Milk intake level	Medium	High	Medium	High
Daily milk consumption, lb.	19.1	25.1	21.0	22.8
Birth weight, lb.	67.9	79.9	89.9	88.2
Weaning weight, lb.[1]	589	644	674	700
Daily gain, lb.[2]	2.17	2.43	2.43	2.55
Conformation grade[3]	11.9	10.9	10.4	11.0
Condition score[4]	5.9	6.8	5.1	4.5

[1]240-day sex corrected weaning weight. Sex correction factor of 1.05 used to adjust heifers to a steer equivalent.
[2]Rate of daily gain adjusted for birth weight.
[3]10 = average good, 11 = high good, 12 = low choice.
[4]1 = very thin, 9 = very fat.

dates with a resulting longer portion of the lactation in late summer would tend to reduce milk production and weaning weight. This is supported by the lower milk production seen for crossbred cows raising crossbred x crossbred calves.

At weaning crossbred x crossbred calves consuming the high levels of milk (25.1 pounds) were 75 pounds heavier than calves receiving the medium milk level (19.1 pounds). This represents a 11 percent increase in weaning weight or an additional 0.26 pounds per day gain. Increased milk consumption was also reflected in condition scores of the calves. Condition scores for crossbred x crossbred calves were 5.9 and 6.8 for the medium and high milk levels. Charolais x Holstein calves receiving the high level (22.8 pounds) were 26 pounds heavier at weaning than calves at the medium level (21.0 pounds). This was a four percent increase in weaning weight or an additional 0.12 pounds of gain per day. As previously mentioned, calving dates may have reduced weaning weights for both the crossbred x crossbred calves on the medium level of milk, and the Charolais x Holstein on the high level.

As milk consumed and rate of gain increased, the apparent efficiency with which milk was utilized for gain decreased (Table 3). Crossbred x crossbred calves receiving the high milk level required 1.5 pounds more milk per pound of gain. This represents a 15 percent decrease in the efficiency of milk utilization by calves at the high level of intake. An additional 23.1 pounds of milk was required to produce an additional pound of gain above that of crossbred x crossbred calves receiving the medium milk level. Charolais x Holstein calves consuming the high milk level required 0.3 pounds more milk per pound of gain compared to calves receiving the medium milk level. This represents a three percent decrease in efficiency of utilization compared to calves receiving

Table 3. Milk conversion efficiency

Breed of calf	Crossbred x crossbred		Charolais x Holstein	
	Medium	High	Medium	High
Milk per lb gain, lb.	8.8	10.3	8.6	8.9
Additional milk per lb. additional gain, lb.	23.1		15.0	

Table 4. Relative forage intake

Breed of calf	Crossbred x crossbred		Charolais x Holstein	
Milk intake level	Medium	High	Medium	High
Actual milk production at trial	13.4	17.4	15.5	16.7
Dry matter intake/day, lb.	4.19	4.75	6.61	4.57
Relative forage intake	100	113	158	109

[1]Expressed as percent of forage intake by crossbred x crossbred calves at the medium milk intake level.

the medium level or an additional 15 pounds of milk to produce an additional pound of weaning weight.

Milk production levels of cows of both breeds were similar and low during August when forage intake of the calves was estimated. The lack of a difference in milk production between the medium and high levels makes interpretation of the data difficult. Based on previous studies at this station, none of the milk production levels at the time of the trial would be expected to affect calf forage intake. The overall greater forage intake by the larger Charolais x Holstein calves may reflect their greater size and capacity to consume forage.

References:

Wyatt, R.D., Leon Knori, M.B. Gould, and Robert Totusek. 1976. Oklahoma Agri. Exp. Sta. MP-96: 38-42.

A Comparison of Milk Production in Angus and Hereford Cattle Under Range Conditions

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Story in Brief

For six consecutive summers from 1967 through 1972 milk production data and calf weights were obtained on 144 Hereford cow-calf pairs and 315 Angus cow-calf pairs. On the average, Angus cows produced 5.05 pounds more milk per day during the six-month lactation period than Hereford cows. The lactational pattern for both Hereford and Angus cows indicated that milk production tended to increase up to the third month of lactation and declined thereafter. On the average, Angus calves consumed 5.05 pounds more milk per day, gained 0.15 pounds more per day to weaning, weighed 32 pounds more at weaning and were fatter at weaning than Hereford calves. Hereford calves

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required 5.95 pounds of milk to produce a pound of gain while Angus calves consumed 8.25 pounds of milk for each pound of gain. Thus, Hereford calves required 27.7 percent less milk per pound of gain than Angus calves. Preweaning calf gain was highly correlated with average daily milk production of the dam in Herefords (0.78) and moderately correlated in the Angus (0.44).

Introduction

The percentage of cows in the herd weaning calves and the weaning weight of those calves constitute the two most important traits affecting net income in a cow-calf operation. Calf weaning weight is jointly determined by the genetic potential of the calf for growth and the amount of milk received from the dam. Genetically improving calf growth rate and/or level of milk production of the cows should result in increased herd productivity as long as reproduction is not adversely affected in the process.

Most beef cattle herd improvement programs place some emphasis on increased growth rate. In order to achieve maximum production, cows in the herd must be capable of producing sufficient milk to allow the calves to attain their full genetic potential for growth. It is important that the cows in the herd, whether purebred or commercial, produce milk at a level sufficient to optimize total production under the management system imposed and for the kind of calves produced.

The purpose of this study was to estimate milk production of Hereford and Angus cows managed under range conditions and to determine the relationship between the cow's level of milk production and calf performance.

Materials and Methods

The study involved 144 Hereford cow-calf pairs and 315 Angus cow-calf pairs. Cattle involved in this study were a sample from a long term genetic improvement study being conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma. Calves were born in February, March, and April and remained with their dams without creep feed until weaning at an average age of 205 days. Cattle were managed on native range and bermuda grass pastures as a single herd except for a 60-day breeding season (May 1 to July 1) when they were allotted to single sire breeding pastures.

Milk production estimates were obtained at monthly intervals from April to September for a period of six years from 1967 to 1972. Milk production was estimated on Hereford cows in 1967 and 1970 and Angus cows in 1968, 1969, 1971, and 1972. The calf suckling technique was used to estimate daily milk yield of the dam. On the day prior to the milk production test, calves were separated from their dams around 10:00 a.m. Calves were returned to their dams at 6:00 p.m. and allowed to nurse. This was simply a pretest milkout in order to place cows and calves on an equal basis relative to udder fill and hunger. After nursing, calves were immediately separated from their dams. At 6:00 a.m. and 6:00 p.m. on the following day, calves were weighed before nursing, allowed to nurse their dams (which took approximately 15-20 minutes) and reweighed immediately after nursing. Difference in pre- and post-nursing weights was used as an estimate of milk production of the dam for a 12-hour period. Thus, the sum of these two 12-hour milk production estimates (6:00 a.m. and 6:00 p.m.) provided an estimate of milk production of the dam for a 24-hour period.

Results and Discussion

Milk production and calf performance vary greatly from year to year due to large fluctuations from one year to the next in general climatic conditions and its influence on the quantity and quality of forage available particularly during the lactation period. Comparisons between Angus and Hereford cattle in this study need to be made with some caution since different years were involved for each breed. However, since several years were involved, the year-to-year fluctuations tend to average out. Thus, the average over two years for Herefords and four years for Angus does provide some indication of the relative level of milk production and subsequent calf performance for these two breeds.

Daily milk yields, cow weights, and calf performances for Hereford and Angus cattle are presented in Table 1. Data have been averaged over two years (1967 and 1970) for Hereford, and fours years (1968, 1969, 1971, and 1972) for Angus. On the average, Angus cows gave 5.05 pounds more milk per day than Hereford cows during the 183-day lactation period measured. Daily milk yield

Table 1. Average Angus and Hereford performances for various cow and calf traits

Trait	Hereford[1]		Angus[1]	
	Average	St. deviation	Average	St. deviation
Number of cow-calf pairs	144	--	315	--
April ADMY[2], lbs.	11.57	3.79	15.43	4.46
May ADMY, lbs.	10.67	3.28	17.10	4.53
June ADMY, lbs.	10.95	3.40	17.45	4.78
July ADMY, lbs.	9.94	3.44	14.58	4.42
August ADMY, lbs.	8.35	4.02	14.19	5.05
September ADMY, lbs.	7.60	3.44	11.10	3.83
Total ADMY (Apr. to Sept.), lbs.	9.88	2.46	14.93	2.78
Preweaning calf ADG, lbs./day	1.66	0.24	1.81	0.25
Adjusted 205-day weaning weight, lbs.	428	48	460	54
Calf weaning condition score[3]	4.04	0.69	4.57	0.75
Fall cow weight, lbs.	1007	116	980	121

[1]Data obtained for Hereford cattle in 1967 and 1970; data obtained for Angus cattle in 1968, 1969, 1971 and 1972.
[2]ADMY = Average Daily Milk Yield.
[3]Condition score equivalents: 1 = very thin to 9 = very fat.

increased gradually from the first to third month of lactation after which it began to decline; whereas, milk production in Herefords decreased slightly the second month, increased the third month, and declined gradually thereafter. Both breeds exhibited a decline in milk production from the first month to the sixth month. Hereford cows reduced their daily milk yield by 3.2 pounds during the lactation period; whereas, the Angus cows in the sixth month averaged only 1.2 pounds less milk per day than during the first month.

The general increase in milk production by the cows during the first three months of lactation coincided with lush growth of spring grass which provided energy needed to reach maximum milk production. As the lactation period progressed, less nutritious grass was available, and this resulted in a decline in daily milk yield.

Another factor that may influence decline in milk production is that calves tend to become less and less dependent on milk from their dams as a major nutritional source as they get older.

The higher level of milk production in Angus cows was reflected in the growth performance of their calves. On the average, Angus calves consumed 5.05 pounds more milk per day, gained 0.15 lb./day more from birth to weaning, were 32 pounds heavier at weaning, and were in fleshier condition at weaning. However, Hereford cows were heavier in the fall at the end of the lactation period than Angus cows.

Table 2 presents correlation coefficients between average daily milk yield of the dams and various cow and calf traits. Correlation coefficients measure the relationship between two traits and range in value from -1 to 1. A correlation of 0 indicates the two traits are unrelated, and a correlation of 1 or -1 indicates perfect correlation. A positive correlation indicates that as one trait increases the other trait also tends to increase; whereas, a negative correlation indicates that as one trait increases the other trait tends to decrease.

Average daily milk yield of the dam was highly correlated with calf preweaning gain and weaning weight (0.78 and 0.77) in Herefords and

Table 2. Correlation coefficients of various traits with the average daily milk yield of hereford and Angus cows

Trait correlated with average daily milk yield	Hereford	Angus
Preweaning calf gain	.78**	.44*
Adjusted 205-day weaning weight	.77**	.46*
Calf weaning condition score	.59**	.35*
Fall cow weight	.26	.25
Average cow weight[1]	.32	.25
Cow weight change[2]	.31	-.04

*Correlations significant at the .05 probability level.
**Correlations significant at the .01 probability level.
[1]Average of spring and fall cow weight.
[2]Cow weight change = fall weight minus spring weight.

moderately correlated (0.44 and 0.46) in Angus. These correlations were large enough to reinforce the idea that preweaning calf growth is highly dependent on milk production of the dam. These data would suggest that 59 percent and 21 percent of the variation in calf weaning weights could be attributed to differences in milk production of the dams for Hereford and Angus, respectively. Increased levels of milk production was associated with a higher degree of fleshiness in calves at weaning as evidenced by the correlations of 0.59 and 0.35 with weaning condition score for Hereford and Angus, respectively.

Although the correlations were not large, there was a tendency within a breed for the heavier cows to produce more milk. The relationship between the change in cow weight from spring to fall and milk yield is somewhat uncertain ranging from a modest 0.31 in Herefords to essentially no relationship -0.04 in Angus. Neither cow weight or weight change would be as useful as indicators of differences in milk production as calf preweaning gain or weaning weights would be.

Table 3 presents information on efficiency of Hereford and Angus calves in utilizing milk to produce weight gain. Efficiency of weight gain from milk consumption was measured as pounds of milk consumed to produce a pound of gain. Angus cows produced a larger amount of milk during the 183-day lactation period than Hereford cows (2732 pounds vs. 1808 pounds). Similarly Angus calves had more total weight gain, on the average, during the same period than Hereford calves (331 pounds vs. 304 pounds). Hereford calves required 5.95 pounds of milk to produce a pound of gain while Angus calves consumed 8.25 pounds of milk to produce a pound of gain. Thus, Hereford calves consumed 27.9 percent less milk per pound of gain than Angus calves. This may mean the Hereford calves were actually more efficient in converting milk to gain, or that Hereford calves consumed more feed other than milk, or a combination of the two. Another possibility is that a pound of milk from a Hereford may supply more nutrients to the calf than a pound of milk from Angus cows, i.e. milk from Hereford cows may have a higher fat content and/or more solids not fat.

In summary, these data provide evidence that Angus cows produced more milk, on the average, under range conditions than Herefords. This merely represents a biological difference between these two breeds and does not mean one or the other is necessarily better. Level of milk production is an important trait to the production efficiency of the herd. Whether or not increased milk production is advantageous depends upon the management

Table 3. Efficiency of calf gain from milk consumption

	Hereford	Angus
Total 183-day milk yield, lbs.	1808	2732
Total calf preweaning gain, lbs.	304	331
Efficiency of gain, lbs. milk/lb. gain	5.95	8.25

system (particularly quantity and quality of forage available) and the genetic potential for growth of the calves produced. If forage is abundant and the cows are being crossed to bulls from larger, growthier breeds, increased milk production may be desired. However, if forage is somewhat limited, increased milk production may result in cows with an inadequate nutritional level to reproduce normally. Whether or not it would be economically feasible to supplement the range nutrition of the cows to permit normal reproduction in this circumstance depends upon the prevailing feed costs and the selling price of additional weaning weight of calves. The producer should strive for a level of milk production in the cow herd that will provide adequate nutrition for the calves produced to maximize profit in most years.

Summer Performance and Forage Intake of Stockers Grazed on Bermudagrass

B.R. Wilson, G.W. Horn and W.E. McMurphy

Story in Brief

Forage intakes of eight steers grazing a 5.4-acre Midland bermudagrass pasture were measured at approximately 28-day intervals from May 24 to September 15, 1976. Digestible dry matter intakes (lb./100 lb. steer body wt.) were not significantly correlated with average daily gains, and accounted for only two percent of the variation of stocker gains. Digestible protein intakes (lb. DP/head/day) were significantly ($P<.01$) correlated with average daily gains and accounted for 38 percent of the variation of gains. The results indicate (1) that protein supplementation for 30 to 45 days during the later part of the bermudagrass growing season, or (2) that pasture management practices that would maintain a high-quality bermudagrass forage throughout the summer may hold stocker weight gains to acceptable levels.

Introduction

A major criticism of bermudagrass is that it will not support acceptable stocker weight gains after the first 60 to 75 days of the growing season. The

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decreased weight gains during the latter part of the bermudagrass growing season are usually attributed to decreased forage intake due to decreased forage quality, or to the concept that bulk-fill limits the intake of this low-quality forage.

The objective of this study was to measure, at monthly intervals, (1) forage intakes and forage protein digestibility, and (2) weight gains of stockers grazed on bermudagrass during the summer.

Materials and Methods

Forage intakes and weight gains of eight steers (626 ± 18.1 pounds average initial weight) grazing a 5.4 acre Midland bermudagrass pasture[1] were measured monthly from May 24 to September 15, 1976, using chromic oxide and *in vitro* dry matter digestibilities of hand-clipped forage samples to calculate fecal output and forage intake, respectively. The eight steers consisted of four Herefords, two Angus, and two Hereford x Angus steers that had been on bermudagrass pastures for about 19 days prior to the first intake trial.

The bermudagrass pasture on which the steers grazed during the intake trials was sprayed with 0.5 pounds of 2,4-D per acre, and fertilized with 60 pounds of nitrogen per acre as ammonium nitrate on May 21 and May 24, respectively. The pasture was mowed twice to a forage height of about three inches on June 6 and July 29. In general, the summer in which these trials were conducted was characterized by an abnormally cold spring that delayed the onset of bermudagrass growth and a dry summer — approximately 50 percent below the average rainfall for May through September. Shade was available to the steers throughout the summer.

The five forage intake trials were begun on May 24, June 21, July 19, August 16, and September 13. During each forage intake trial, the steers were bolused with four grams of chromic oxide in gelatin capsules twice daily (8:00 am and 4:00 pm) during a five-day preliminary period and a three-day fecal collection period, in which fecal samples were taken each time the chromic oxide boluses were given. The steers were weighed on two consecutive days during each intake trial, and six hand-clipped forage samples were taken from the pasture. Protein digestibility of the bermudagrass during each intake trial was determined by the lignin ratio method.

Results and Discussion

Table 1 shows the bermudagrass dry matter digestibility, crude protein content, protein digestibility, and digestible protein content during each of the five intake trials; and the intakes of forage dry matter, digestible dry matter, and digestible protein. Dry matter digestibility of the available forage was significantly greater ($P<.01$) in May; decreased slightly in June; and declined

[1]Southwestern Livestock and Forage Research Station, El Reno, Oklahoma.

Table 1. Bermudagrass quality, forage and digestible protein intakes during intake trials[1]

Item	May	June	July	August	Sept
Dry matter digestibility, %	55.9[a]	53.8[a]	43.5[b]	40.1[b]	43.0[b]
Crude protein, %	20.4[a]	17.2[b]	12.8[c]	9.3[d]	9.0[d]
Protein digestibility, %	63.7[a]	39.2[b]	41.3[bc]	24.4[d]	48.0[c]
Digestible protein, %	13.0	6.7	5.3	2.3	4.3
Forage, intake					
Dry matter, lb./steer/day	12.9[a]	14.5[ab]	13.3[a]	14.8[ab]	15.1[b]
Digestible dry matter, lb./100 lb. steer body wt.	1.16[a]	1.16[a]	.80[b]	.80[b]	.90[b]
Digestible protein, lb./steer/day	1.7[a]	1.0[b]	.7[c]	.3[d]	.7[c]

[1]Means in the same row with different lettered superscripts are significantly different (P<.01).

further to values of 43.5, 40.1 and 43.0 percent during the July, August, and September intake trials, respectively. Crude protein content of the forage decreased throughout the summer to a low of 9.0 percent during the September trial. Forage protein digestibility decreased markedly from May to June, and was lowest during the August trial. The digestible protein content of the forage decreased from May to August, and increased slightly in September.

Intake of digestible dry matter (lb./100 lb. steer body weight) was the same during the May and June intake trials, but was significantly decreased (P<.01) during July, August, and September. Digestible protein intake (lb./steer/day) decreased from May to August, then increased in September.

Average stocker weight gains, digestible dry matter, and digestible protein intakes between intake trials are shown in Table 2. Average daily gains of the stockers increased slightly from May-June to June-July, then decreased significantly (P<.01) to a low of 0.35 pounds in the July-August period, and increased in the August-September period. Average daily gain for the 112-day trial was 1.3 lb./steer/day. The decrease in digestible dry matter intake (lb./100 lb. steer body weight) in the July-August period was not large enough

Table 2. Average daily gains, digestible dry matter and digestible protein intakes of stockers grazed on bermudagrass[1]

	May-June	June-July	July-August	August-September
Average daily gain, lb.	1.63[a]	2.09[a]	0.35[c]	1.09[b]
% of May-June	---	128	21	67
Digestible dry matter intake[2], lb/100 lb. steer body weight	1.16	0.98	0.80	0.85
% of May-June value	---	84	69	73
Digestible protein intake[2], lb/steer/day	1.34	0.85	0.53	0.53
% of May-June value	---	63	40	40

[1]Mean in the same row with different lettered superscripts are significantly different (P<.01).

[2]Values are averages of May and June, June and July, July and August, August and September intakes.

to account for the decreased gains. Regression of average daily gain on digestible dry matter intake (lb./100 lb. steer body weight) resulted in a non-significant correlation coefficient of 0.15, and accounted for only about two percent of the variability in observed gains. This suggests that factor(s) other than forage quality, as usually evaluated, attribute to the variability of stocker gains on bermudagrass.

The decrease in digestible protein intake (lb./steer/day) for the July-August period more closely reflects the depressed gain for that period. Regression of average daily gain on digestible protein intake results in a low but highly significant correlation coefficient ($P<.01$) of 0.61 and can account for 38 percent of the variation in observed gains. This data suggests that supplementation with protein for 30 to 45 days during the latter part of the bermudagrass growing season may hold stocker weight gains on bermudagrass to acceptable levels by (1) supplying needed digestible protein, and (2) increasing ruminal dry matter digestibility and hence forage intake.

The challenge, however, in utilizing bermudagrass pastures in summer stocker programs is to supply an adequate amount of immature, high-quality forage on a continuous basis. Based on the results of stocker grazing trials on Coastal bermudagrass at the North Louisiana Hill Farm Experiment Station (Homer, Louisiana) that have produced over 750 and 625 lb of stocker gain per acre with yearling steers and spring-weaned calves, respectively, (Table 3) the following recommendations are made:

1. Begin grazing early in the bermudagrass growing season when forage growth is no more than 2 to 3 inches tall.
2. Use a heavy stocking rate — 3 to 5 head per acre. Bermudagrass forage growth must be removed as fast as it grows if young, high-quality forage is to be kept available. The average age of accumulated bermudagrass forage growth should not exceed 3 weeks for stockers.

Table 3. Production data for stocker cattle grazed on Coastal bermudagrass at the North Louisiana Hill Farm Experiment Station (Homer, Louisiana)

	No. days	No.	Stocking rate/acre		Gain, lbs per			Nitrogen applied	Lb gain per
Year	grazed	cattle	Head	lbs	Day	Head	Acre	per acre	pound N
				Yearling steers wintered on hay					
1975	120	32	3.2	1671	1.89	227	726	258	2.81
1975	119	48	3.0	1326	1.94	231	692	225	3.08
1976	154	39	3.9	1679	1.47	226	884	400	2.21
1976	147	96	3.0	1510	1.76	259	777	350	2.22
				Spring weaned calves					
1975	156	108	3.0	1036	1.37	214	642	267	2.40
1976	141	40	5.0	1636	1.06	148	744	350	2.12
1976	141	32	4.0	1272	0.93	132	525	350	1.54

Wheat Pasture Bloat of Stockers

G. W. Horn, B. R. Clay and L. I. Croy

Story in Brief

Ruminal motility and foam stability, and expansion and strength measurements of foamed rumen fluid samples (as estimates of the potential of bloat occurring in stockers) were made during the 1975-1976 wheat pasture season. Also, the chemical composition of wheat forage samples taken during the spring of 1973 from pastures (1) where bloat was not observed, and (2) where stockers were bloating or had died of bloat was characterized. The ruminal motility data indicate that wheat pasture bloat of stockers does not occur secondarily to a reduced ruminal motility. Significant differences were observed in the measurements of ruminal fluid foam stability, expansion, and strength at various times during the grazing season.

No significant relationships were found between the ruminal fluid foam stability measurements and dry matter, crude protein, foam-stabilizing protein (ribulose 1,5-diphosphate carboxylase), and soluble carbohydrate concentrations of wheat forage samples taken on the same days that foam stability measurements were made. Wheat forage samples from bloat-provocative pastures contained less dry matter and significantly less ($P<.05$) total fiber (neutral-detergent fiber). The concentrations of crude protein and soluble nitrogen fractions (total soluble N, and soluble protein N, and soluble non-protein N) of forage samples from bloat provocative pastures were all significantly increased. The data indicate that wheat forage maturity or age of accumulated forage growth may be a major factor which affects the incidence of bloat.

Introduction

Frothy bloat is a major cause of deaths in wheat pasture stockers that die of the stocker syndrome. Death losses due to the stocker syndrome are believed to be in the range of two to three percent, and have been as high as 20 percent on some wheat pastures. Some basic points relative to the etiology and prevention of frothy bloat in wheat pasture stockers are: (1) Bloat occurs when the rate of eructation or removal of rumen fermentation gases is less than the rate of production. This may result from an increased rate of production of gases or from impaired function of the rumen, cardia, or esophagus. (2) Rumen fermentation gases may become entrapped in ruminal fluid froth or foam, and cannot be eructated regardless of the functionality of the rumen and other digestive organs, and (3) The chemical composition of wheat forage changes, depending upon environmental growing conditions, stage of wheat plant growth or maturity and fertility level, and, therefore, would be expected to affect the degree or likelihood that a stable ruminal foam would be formed when wheat forage is grazed by stockers.

The objectives of the studies reported herein were: (1) to measure ruminal motility of stockers grazed on wheat pasture since secondary ruminal contractions are required for eructation of ruminal fermentation gases, (2) to determine the potential of bloat occurring in stockers, and (3) to assess the possible relationships between the bloat potential and chemical components of wheat forage samples taken during the 1975-1976 wheat pasture grazing season. In addition, the chemical composition of wheat forage samples taken during the spring of 1973 from pastures where stocker bloat was not observed, and where stockers were bloating or had died of bloat were characterized.

Materials and Methods

Wheat pasture and steers

Eight acres at the O.S.U. Dairy Cattle Center were seeded on September 8, 1975, with 104 pounds of Triumph 64 seed per acre. Urea (143 lb/acre) was applied immediately before drilling, and 48 lb./acre of 18-46-0 fertilizer was applied with the seed. Total nitrogen applied per acre at planting was, therefore, approximately 73 lb./acre. No additional nitrogen was applied during the remainder of the grazing season.

Four ruminal cannulated Hereford steers that weighed 475 ± 15 pounds were placed on the pasture on November 10, 1975; and four additional Hereford steers that weighed 548 ± 31 pounds were placed on the pasture on December 31, 1975. The average daily weight gains of these cattle from the time that they were put on the wheat pasture until April 26, 1976, was 2.05 ± .10 lb./head/day, and reflect the large amount of wheat forage that was available to them.

Ruminal motility

Ruminal motility of three of the four steers which had been placed on pasture on December 31, 1975 was measured at approximately weekly intervals from January to April 2, 1976 by means of pressure transducers surgically implanted in the rumen.

Ruminal fluid foam stability, expansion and strength

Measurements of foam stability, expansion, and strength were made on ruminal fluid samples taken from the four rumen cannulated stockers at approximately weekly intervals from December 23, 1975 to April 1, 1976. Rumen fluid samples were foamed in glass columns by passing compressed air through a fritted glass disc for 10 minutes at constant pressure. Foam stabilities were estimated from the slopes (regression coefficients) of the resulting plots of foam height versus foaming time. Foam stability increased as the magnitude of the regression coefficients increased. Foam expansion, and strength were measured as the number of volumes of foam obtained from one volume of fluid (cm. foam/cm. fluid) at the end of the 10 minute foaming time, and as the rate of fall (cm./sec.) of a perforated brass weight through the produced foams, respectively.

Field trial data

Wheat forage samples were collected during the spring of 1973 from wheat pastures where bloat was not observed in stockers, and where stockers were bloating or had died of bloat. The samples were kept frozen in a freezer until they were analyzed.

Results and Discussion

Ruminal motility

The mean amplitude and frequency of ruminal contractions during the pre-wheat pasture control period in which the steers were fed a high cottonseed hull diet, and the wheat pasture grazing period are listed in Table 1. There were no significant differences among the mean amplitudes and frequencies of ruminal contractions measured at the various times during the wheat pasture grazing period. Therefore, the data shown in Table 1 represent the mean amplitude and frequency of ruminal contractions for the entire wheat pasture grazing period. The mean amplitude of ruminal contractions measured during the wheat pasture grazing period were significantly increased ($P<.05$) by a magnitude of two-fold. Extremely large amplitudes, in the range of 40 to 50 mm. Hg, of ruminal contractions were frequently observed during the wheat pasture grazing period. The frequency of ruminal contractions was only slightly increased (1.1-fold) during the wheat pasture grazing period. Reduced ruminal motility patterns, as compared with pre-wheat pasture motility patterns, were not observed at any time during the wheat pasture grazing period.

The increased amplitudes of the ruminal contractions that were observed are probably indicative of the large forage intakes of wheat pasture stockers. In

Table 1. Ruminal motility[1] of wheat pasture stockers

	Pre-wheat pasture control period	Wheat pasture grazing period	Fold increase[2]
Amplitude, mm. Hg	10.4 ± 1.8	21.1* ± 1.1	2.0
Frequency, sec.	32.7 ± 2.1	35.8 ± 1.7	1.1

[1]Mean ± standard error of mean for amplitude and frequency of ruminal contractions.
[2]Fold increase during wheat pasture grazing period over pre-wheat pasture, control period.
*Significantly greater ($P<.05$) than mean of pre-wheat pasture amplitudes.

general the ruminal motility data indicate that wheat pasture bloat of stockers does not occur secondarily to a reduced ruminal motility or ruminal stasis.

Ruminal fluid foam stability, expansion and strength

Table 2 shows the foam stability, expansion, and strength measurements of ruminal fluid samples taken from stockers at various times during the 1975-76 wheat pasture grazing period. The initial foam stability measurement (12-23-75) has been assigned a relative value of 100 percent, and the magnitudes of the remainder of the measurements of foam stability are expressed as a percentage of the initial value. Ruminal fluid foam stabilities were significantly ($P<.05$) increased (420 percent of initial value) on 3-11-76. Foam stabilities on 2-12-76 and 3-5-76 were significantly lower ($P<.05$) than those measured on 1-22-76 and 2-26-76. An explanation as to why the least and most stable ruminal foams occurred only six days apart (3-5-76 vs. 3-11-76) is not apparent. It is not likely that the composition of the grazed wheat forage would have changed enough during this six-day period to effect these extreme differences in the foam stability measurements. Measurements of ruminal fluid foam expansion and strength were the highest on 3-11-76, and the lowest foam expansions occurred on 2-12-76, and 3-5-76 which coincided with the foam stability measurements.

No significant relationships were found between the ruminal fluid foam stability mesurements and dry matter, crude protein, foam-stabilizing protein (ribulose 1,5-diphosphate carboxylase), and soluble carbohydrate concentrations of wheat forage samples taken on the same days that foam stability measurements were made. Coefficients of determination (R^2 values) indicated

Table 2. Rumen fluid foam stability, expansion and strength measurements

	Stability			
Date	Linear regression coefficients	Percent of initial value	Expansion (Cm. foam/cm. fluid)	Strength (cm./sec.)
12-23-75	.396[ab]	100	7.48[ab]	- - - -
12-30-75	.268[ab]	68	4.26[ab]	- - - -
1-15-76	.303[ab]	77	6.25[ab]	1.92[a]
1-22-76	.564[b]	142	9.20[ab]	2.18[a]
1-29-76	.193[ab]	49	3.88[ab]	2.45[a]
2-12-76	.061[a]	15	2.49[a]	2.58[a]
2-19-76	.419[ab]	106	7.68[ab]	1.92[a]
2-26-76	.618[b]	156	9.79[b]	3.80[a]
3-5-76	.010[a]	3	2.58[a]	2.95[a]
3-11-76	1.665[c]	420	26.16[c]	10.78[b]
3-17-76	.366[ab]	92	7.27[ab]	2.65[a]
3-25-76	.387[ab]	98	8.28[ab]	4.50[a]
4-1-76	.393[ab]	99	8.57[ab]	2.35[a]

[a,b,c]Means in the same column that have common lettered superscripts are not statistically different ($P>.05$).

that only 0.57, 3.81, 3.88, and 1.80 percent of the total variation in foam stabilities was accounted for by the dry matter, crude protein, foam-stabilizing protein and soluble carbohydrate concentrations, respectively.

Field trial data

The results of the chemical analyses of wheat forage samples taken during the spring of 1973 from pastures where stocker bloat was not observed and where stockers were bloating or had died of bloat are shown in Table 3. Wheat forage samples from bloat-provocative pastures contained less dry matter, and significantly less ($P<.05$) total fiber (neutral-detergent fiber). The concentrations of crude protein and soluble nitrogen fractions (total soluble N, soluble protein N, and soluble non-protein N) of forage samples from bloat provocative pastures were all significantly increased ($P<.05$). The extent to which the analyses in Table 3 reflect stage of wheat forage growth or age of accumulated forage growth is not known. The data in Table 3 do suggest, however, that a subtle relationship (Figure 1) may exist between (1) climatic (growing) conditions, (2) soil fertility management, and (3) stocking rates as they affect the age of accumulated forage growth, forage maturity and the incidence of bloat.

Wheat forage of several or many days accumulated growth would be more fibrous and less succulent than wheat forage of only a few days growth. Stockers grazing the more fibrous, less succulent wheat forage may secrete greater quantities of saliva during the chewing associated with eating and during the re-chewing of regurgitated boluses. The increased amounts of saliva may have an anti-foaming effect, and thus reduce the incidence of frothy bloat. The significantly decreased total fiber content (neutral-detergent fiber) of wheat forage samples from pastures where stockers were bloating supports this rationale. From a practical standpoint, wheat pasture stockers that are

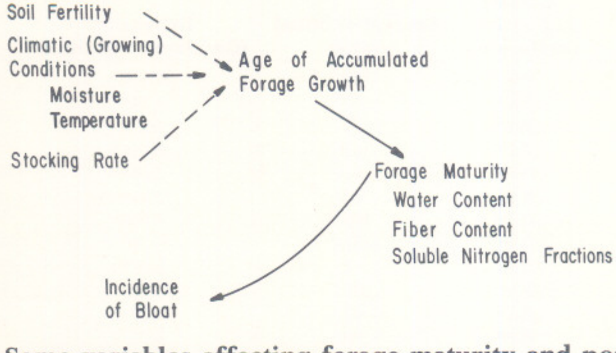

Figure 1. Some variables affecting forage maturity and possibly the incidence of bloat in wheat pasture stockers.

Table 3. Chemical composition of wheat forage where bloat was not observed and bloat-provocative pastures

Wheat pasture	Bloat not observed	Bloat-provocative pastures
Number of samples	9	7
Dry matter (DM), %	28.48	22.31
Total fiber		
(Neutral-detergent fiber)	44.59	35.02*
Crude protein, %	25.40	31.75*
Soluble nitrogen		
% of DM	1.85	3.24**
% of total N	44.94	61.79*
Soluble Protein Nitrogen		
% of DM	0.79	1.30*
% of total N	19.07	24.53
Soluble non-protein nitrogen		
% of DM	1.06	1.94**
% of total N	25.84	37.18**
Soluble carbohydrate, %	13.09	9.27

Significantly different from wheat forage samples taken from pastures where bloat was not observed: *(P<.05); **(P<.01).

frequently seen "chewing their cuds" may be less likely to bloat than those that are not. Also freeze-burned, dormant wheat forage is not likely to cause bloat.

Plant Chemical Composition and Digestibility of Rangeland Forage

S.H. Kautzsch, D.G. Wagner, J. Powell and R.W. Hammond

Story in Brief

Forage samples were collected on a monthly basis from various points on a watershed. Both live and standing dead plants were collected. At the various sampling points both caged (C) and grazed (G) vegetation was sampled. Fiber (ADFP), lignin (ADLP) and cellulose (CELLP) data were very similar in both the caged (live and dead) and grazed (live and dead) samples for the months of June, July and August. Fiber data showed CLADFP, CDADFP, GLADFP,

and GDADFP were 37.3, 51.9, 37.5, 51.4 percent for June vs. 47.8, 50.6, 39.0, 51.1 percent for August, respectively. Lignin for CLADLP, CDADLP, GLADLP, and GDADLP was 8.2, 12.8, 12.6, 12.2 percent for June vs. 10.4, 11.1, 10.3, 14.8 percent for August, respectively. Cellulose for CLCELLP, CDCELLP, GLCELLP, and GDCELLP was 30.6, 36.5, 31.2, 36.4 percent for June vs. 30.2, 37.5, 30.0, 37.7 percent for August, respectively.

Invivo digestion data was similar with the forage in June being less digestible than expected for that point in the growing season. Digestibility (DMD) for CLDMD, CDDMD, GLDMD, and GDDMD was 35.9, 18.5, 35.8, 3.1 percent for June vs. 47.8, 22.4, 50.4, 22.0 percent for August.

Introduction

There has been much interest in recent years given to animal waste pollution. Most of the interests are directed at point sources of pollution (e.g., feedlots) or nonpoint sources such as cropland or intensively managed pasture land.

With high grain prices and a greater demand abroad for grain for human consumption, more emphasis in the future will be placed on greater forage utilization in beef production systems. Much of the additional forage will have to come from rangeland, requiring more efficient rangeland forage production. Consequently, there will be a need for greater understanding of range ecosystems.

Recently, larger numbers of cattle have been maintained on rangeland because of the economic plight in the beef cattle industry. If proper management is not practiced, rangelands will be overstocked and overgrazed. Improper stocking rates and overgrazing could lead to greater water pollution from feces produced by livestock grazing rangeland, as a result of increased runoff.

The purpose of this study was to determine the interrelationships between plant chemical composition and animal waste chemical composition. Digestibility relates the effects of quality of forage with plant chemical composition. The data available at this time includes a limited amount of plant chemical composition and digestibility of range forage components.

Materials and Methods

The study area consists of a 28.3 acre watershed located at the northwest end of Lake Carl Blackwell in Noble County, Oklahoma. Forage samples were collected on a monthly basis from various points on the watershed. Three small (0.2 acres each) cattle enclosures were constructed along the upper edge of the watershed ridgeline to serve as a control. Both live and standing dead plants were collected. At the sampling points both caged and grazed vegetation was sampled. Grazing utilization, species composition, and forage production were determined on both caged and grazed sampling points. On grazed sampling points, cover, ground litter, and surface soil temperature were determined.

Three Holstein steers (898 pounds) were fitted with rumen cannulae on May 5 for the purpose of running nylon bag *in vivo* digestion trials. The steers were put on four acres of native range pasture on May 20. The grasses were of the same species as those on the watershed. Samples were run on a monthly basis to correspond with the collection period of the forage. *In vivo* nylon bag dry matter disappearance was determined for 48 hour incubation periods.

Results and Discussion

Chemical composition data are shown in Tables 1, 2, and 3. Fiber content as shown in Table 1 are very similar during each of the three months. Caged data was unavailable at this time for the month of July. Caged and grazed live samples were almost identical in June, but showed some difference in August. Caged and grazed dead forage did not show any difference. As shown in Table 2, lignin content during the month of June was 8.2 percent CLADLP vs. 12.6

Table 1. Chemical composition of caged live and dead vs. grazed live and dead forage acid detergent fiber content

Materials	June %	July %	August %
CLADFP	37.3		47.8
CDADFP	51.9		50.6
CLADFP	37.5	39.0	39.0
GDADFP	51.4	53.2	51.1

Table 2. Chemical and composition of caged live and dead forage acid detergent lignin content

Materials	June %	July %	August %
CLADLP	8.2		10.4
CDADLP	12.8		11.1
GLADLP	12.6	9.4	10.3
GDADLP	12.2	14.4	14.8

Table 3. Chemical composition of caged live live and dead vs. grazed live and dead forage cellulose content

Material	June %	July %	August %
CLCELLP	30.6		30.2
CDCELLP	36.5		37.5
GLCELLP	31.2	31.6	30.0
GDCELLP	36.4	38.0	37.7

Table 4. ***In vivo*** **dry matter disappearance of caged live and dead vs. grazed live and dead forage**

Materials	June %	July %	August %
CLDMD	35.9		47.8
CDDMD	18.5		22.4
GLDMD	35.8	43.8	50.4
GDDMD	3.1	7.3	22.0

percent GLADLP. A possible explanation for this slight increase in the caged over the grazed sample values could be species composition within the sample. If the sample of grazed forage consisted of more fibrous-type plant material this increase in lignin content could be justified. The August composition was almost identical in lignin content. The caged and grazed dead forage for August also followed somewhat the same patterns as the June caged and grazed live forage samples. Cellulose data as presented in Table 3 shows that there was very little difference in chemical composition during the two months of June and August.

Digestibility data as shown in Table 4 indicates a slow start in the spring for the growing season. One would expect the forage DMD for both the caged and grazed live forage to be much higher than 35.9 vs. 35.8 percent, respectively, during June. The values for August are somewhat higher than those for June, but very similar to each other. The caged and grazed dead DMD values are almost identical for the month of August.

The data presented here do not show any striking differences between those forages collected in late spring and late summer. This could be due in part to a lack of rainfall in the early spring to stimulate the regrowth of the forages. Consequently, some adapted perennial plants may have gone into dormancy in the dry season pulling nutrient reserves into the roots and leaving the aerial part with a low nutritive value. Temperature increases metabolic activity, and plants tend to accumulate cell wall structures containing lignin and cellulosic carbohydrates. It has been shown that increasing temperature promotes a lowering of nutritive value at the same physiological age in grasses. The above reasons of temperature and rainfall could possibly explain the reason why the chemical composition of the forage at different stages of the growing season are so similar in nature.

Monensin for Wheat Pasture Stockers: Ruminal Fermentation, Forage Intake and Performance

G. W. Horn, F. N. Owens, S. L. Armbruster
V. L. Stevens and M. L. Scott

Story in Brief

Steers grazed on wheat pasture and fed 200 mg. of monensin per day had higher ruminal pH values, lower total ruminal VFA concentrations, and lower ruminal ammonia concentrations. The acetic:propionic acid ratio of steers fed monensin was decreased by about 40 percent. Calculated amounts of ruminal methane produced were decreased about 15 percent in steers fed monensin. Forage intakes of steers fed monensin and grazed on wheat pasture were slightly (12 percent) greater ($P > .05$) than that of steers fed no monensin.

Introduction

Rumensin[1] (monensin sodium) is a feed additive marketed to improve feed efficiency of feedlot cattle. Feeding rumensin to *feedlot* cattle, at a level of 30 grams per ton of feed, does not alter weight gains. Although monensin is not presently cleared by the FDA to be fed to *stocker* cattle grazed on forages, rumensin has been reported to increase weight gain by 10 to 15 percent or more.

The objective of this study was to determine the effect of monensin on (1) ruminal fermentation, (2) forage intake, and (3) weight gain of stocker cattle grazed on wheat pasture.

Materials and Methods

Ruminal Fermentation Studies

During April 7 to 22, 1976, four ruminally cannulated Hereford steer calves were fed two supplements (control and monensin) in a switchback design. During each period (7 day preliminary, 1 day sampling) two steers were individually fed 200 mg. of monensin daily mixed in 0.5 pounds of the ration[2], and two steers were fed 0.5 pounds daily of the same ration without any added monensin. On sampling days, rumen fluid samples were taken at

[1]Trade name of Elanco, Division of Eli Lilly and Co., Indianapolis, Indiana.

[2]Ration consisted of the following (as-fed basis): Ground corn, 62.75 percent; cottonseed hulls, 14 percent; soybean meal, 10 percent; dehydrated alfalfa pellets, 6 percent; molasses, 5 percent; and minerals, 2.25 percent.

four and 24 hours after supplement feeding for pH, volatile fatty acid (VFA), and ammonia analyses. All steers grazed wheat pasture between feedings and samplings.

Forage Intake Trials

Eight crossbred calves grazing a single wheat pasture were randomly assigned to two treatments. All steers were dosed with four grams of chromic oxide in gelatin capsules twice daily (8:00 a.m. and 4:00 p.m.) for a ten-day period. During this period, four of the eight steers received 200 mg. of monensin added to the chromic oxide capsules given at the morning dosage. On days eight, nine, and ten, fecal samples were collected at each of the dosage times. Chromic oxide (an indigestible marker) and *in vitro* dry matter digestibilities of handclipped forage samples were used to calculate fecal output and forage intake, respectively.

Performance Trials

Cooperative trials are being conducted in which gains of wheat pasture stockers fed 200 mg. of monensin/head/day in a pelleted feed or monensin-containing blocks free-choice will be compared with weight gains of stockers fed no monensin. These cattle have not been weighed off test and no data are available at this time.

Results and Discussion

Ruminal Fermentation Studies

The pH of rumen fluid samples was increased, and the total VFA (Table 1) concentrations were decreased in steers fed monensin on wheat pasture. The magnitude of these differences due to monensin was less at 24 hours after feeding monensin than at four hours after feeding monensin. The changes in rumen fluid pH and total VFA concentrations due to monensin suggest that either the steers fed monensin had consumed less wheat forage, or that ruminal digestibility of the wheat forage consumed by the steers fed monensin was decreased. Recent studies by Owens[3] have shown a 10.2 percent reduction in ruminal dry matter digestibility of steers fed an 85 percent concentrate ration containing 17 percent crude protein.

The Molar percentages of ruminal acetic and propionic acids were decreased and increased, respectively, in steers fed monensin, and the magnitude of these changes was similar at four and 24 hours after feeding. The rumen acetic:propionic acid ratio of steers fed monensin was decreased by 40.3 and 40.0 percent at four and 24 hours after feeding monensin.

[3]Unpublished results.

Table 1. Effect of monensin on ruminal fermentation of wheat pasture stockers

	Control	Monensin[1]
4 Hr Post-feeding		
pH	6.22	6.75*
NH_3, mg/100 ml	19.38	16.81
Total VFAs, umoles/ml	219.8	166.0*
VFA molar percentages		
Acetic	65.86	59.14*
Propionic	16.40	25.03*
Butyric	13.28	10.78
Valeric	0.96	0.96
Isovaleric	1.98	2.88*
Acetic:propionic ratio	4.04	2.41*
24 Hr Post-feeding		
pH	6.15	6.48
NH_3, mg/100 ml	20.31	14.84
Total VFAs, umoles/ml	214.6	191.5
VFA molar percentages		
Acetic	67.30	60.32*
Propionic	16.32	24.80
Butyric	12.29	9.80
Valeric	0.90	0.94
Isovaleric	1.89	2.74
Acetic:propionic ratio	4.17	2.50

[1]200 mg./head/day
*Significantly different from control (P<.05).

The relative amount of gases (CO_2 and CH_4) produced in the rumen was decreased as the acetic:propionic acid ratio decreased. Consequently feeding of monensin to wheat pasture stockers might decrease the incidence of bloat. Gas production calculated (Table 2) from the relative production of acetic, propionic and butyric acids indicate that the amount of total gas (CO_2 plus methane) produced per unit of feed digested in the rumen was reduced by 8 percent by monensin feeding. Methane production was decreased by approximately 15 percent in steers fed monensin. The reduction in methane may be more important than the reduction in carbon dioxide plus methane, from the standpoint of wheat pasture bloat of stockers, in that a greater percentage of the methane than of carbon dioxide would have to be eructated. Further, if monensin reduces the extent of ruminal digestion of wheat forage dry matter and forage intake, reduction in gas would be even greater.

The ruminal ammonia concentrations of steers fed monensin was decreased at both sampling times. The magnitude of the decrease was about two-fold greater at 24 hours (26.9 percent) after feeding monensin than at four hours (13.3 percent) post-feeding. The decreased ruminal ammonia concentrations of steers fed monensin suggest that less forage protein was degraded

Table 2. Effect of monensin on calculated quantities of carbon dioxide and methane produced by ruminal fermentation

Hr. post-feeding of monensin:	4		24	
	Control	Monensin	Control	Monensin
$CO_2 + CH_4$, ml/g				
glucose digested	164.7	151.4	164.7	151.4
% reduction over control	- - -	8.07	- - -	8.07
CH_4, ml/g				
glucose digested	63.2	53.8	64.0	54.6
% reduction over control	- - -	14.87	- - -	14.68

Table 3. Effect of monensin on forage intake of wheat pasture stockers

	Control	Monensin
Steer body wt., lb.	492 ± 5.5	496 ± 4.6
Wheat forage intake		
lb. dry matter/steer/day	16.0 ± 1.0	18.1 ± 1.4
lb. dry matter/100 lb. body wt.	3.26 ± 0.17	3.64 ± 0.25

in the rumen. This would likely be beneficial to wheat pasture stockers in that ruminal ammonia concentrations often exceed those believed to be required by bacteria for maximum ruminal dry matter digestion.

Forage Intake Trials

Steers grazing wheat pasture and fed 200 mg. of monensin per day consumed 13.1 percent more wheat forage dry matter/head/day and 11.7 percent more forage dry matter per 100 pounds body weight per day than steers fed monensin ($P>.05$). Additional trials are presently underway to further evaluate the effect of monensin on forage intake of wheat pasture stockers.

The Influence of 48-Hour Calf Separation on Calf Growth Rate and Milk Production in Postpartum Range Cows

T.W. Beck, R.P. Wettemann, E.J. Turman, T.A. Hoagland, L.W. Brock, M.T. Fournier and R. Totusek.

Story in Brief

Fifty-two Hereford cows calving between March 1 and April 26, 1976, were paired by calving date and divided into two groups. Control cows remained with their calves on pasture. At 50 to 80 days after calving the second group of calves was trucked to a pasture one mile away from their dams. The calves were returned 48-hours later. Milk production and calf weights were measured at one and two weeks before, and one and three weeks after calf separation.

Neither milk production nor calf growth rate were affected by calf separation. Therefore, if 48-hour calf separation is shown to be an effective treatment regime to initiate estrous cycles after calving, the separation would not have any detrimental effects on milk production and calf growth.

Introduction

A major problem in range cattle is prolonged postpartum anestrous, that is the absence of estrous cycles after calving, in a substantial number of the cows in a herd. Basic research indicates that the ovary is not functioning during this period and that the lack of gonadotropic hormone release from the pituitary gland is responsible for this anestrus. Recent evidence indicates that the suckling stimulus, acting through nerve pathways, inhibits the release of the gonadotropic hormones. Other studies indicate that cows with greater suckling intensities have longer postpartum anestrous periods.

Recently treatments regimes to initiate estrus have been reported from other experiment stations which include hormone treatments in combination with 48-hour calf separation. The purpose of this experiment was to determine if 48-hour calf separation from cows affect the lactational performance of range cows or weight gains of their calves.

Materials and Methods

Twenty Hereford cows, calving between March 1 and March 29, 1976, were paired by calving date and divided into two groups at 50 to 80 days after calving. One group of calves was removed from their dams for 48-hours and held in a lot approximately one mile away. Calves were given free choice to alfalfa hay and creep feed during the time they were separated from their dams. Control cows remained with their calves on pasture. Estimates of 24-hour milk production were made at one and two weeks before, and one and three weeks after calf separation using the calf suckle technique. A second replication of the above experiment was conducted using 32 cows which calved between March 30 and April 26, 1976.

Results and Discussion

There was no effect of 48-hour calf removal on the milk production of Hereford range cows (Figure 1). There was an effect of time on milk production which could be the normal decline in milk production which occurs after 60 days postpartum or the result of the handling of the animals.

Growth rate of the calves was not altered by 48-hour separation from their dams (Figure 2). Both groups of calves gained 0.64 kg/day through three weeks after treatment. The average 205-day adjusted weaning weight for the control calves was 175.9 kg and the separated calves averaged 182.4 kilograms.

Cows were observed for estrus before and after calf separation using sterile bulls with chinball makers. It appeared that the treatment influenced some of the cows (Table 1). In the first replication, eight out of ten anestrous cows that were separated from their calves were in estrus within ten days after separation, whereas only four out of 11 control cows were in estrus. Environmental factors such as nutrition and temperature may have influenced the responses observed after calf separation.

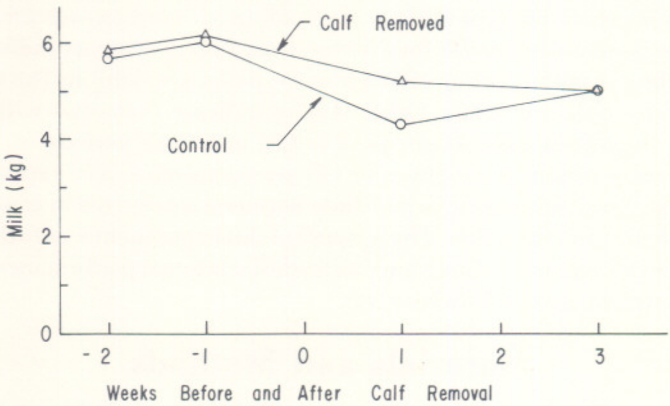

Figure 1. Influence of 48-hour calf separation on milk production in range cows.

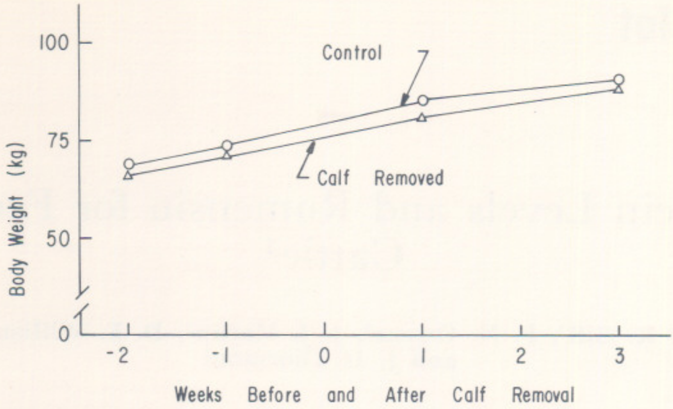

Figure 2. Influence of 48-hour calf separation on calf weight gain.

Table 1. Cows in estrus within 10 days after being separated from their calves for 48 hours at 50 to 80 days post partum

	Control cows	Separated cows
Replicate 1 (May 18)	4 of 11	8 of 10
Replicate 2 (June 15)	2 of 13	3 of 16

These results indicate that if 48-hour calf separation proved effective as a method for decreasing postpartum anestrous, the separation would not have a detrimental effect on milk production, calf growth or 205-day adjusted weaning weight.

Feedlot

Protein Levels and Rumensin for Feedlot Cattle[1]

D. R. Gill[2], F. N. Owens[2], J. J. Martin[3], D. E. Williams and J. H. Thornton[2]

Story in Brief

One-hundred sixty yearling steers were fed whole shelled corn rations for 155 days at Panhandle State University, Goodwell, Oklahoma. Cattle initially averaged 574 pounds, and were fed rations with soybean meal added to provide 9.5, 10.3, 11.2, and 12.3 percent crude protein with or without added rumensin. As protein levels increased, rate of gain during the trial increased by 7 percent, and feed efficiency improved by 5 percent. Gains were increased by higher protein levels only for steers under 850 pounds. Rumensin did not effect rate of gain, but reduced feed intake by 4 percent, and improved feed efficiency by 5 percent. An interaction of rumensin and protein level was apparent, with rumensin depressing feed intake and rate of gain most at the higher protein levels. Feed efficiency advantage with rumensin feeding was greatest with low protein rations. Backfat thickness and yield grade were slightly higher with higher protein levels. Liver abscess incidence was higher with added rumensin. Results suggest that rumensin may spare protein.

Introduction

To compensate for decreased feed intake when rumensin is fed, a higher protein level might be needed. But work in 1975 (Martin, *et al.*) suggested that protein level for steers may not need to be increased with rumensin. Review of the literature (Elanco, 1977) suggests that rumensin may be more beneficial at lower protein levels.

The objective of this work was to determine the optimal protein levels for growing steers fed corn grain-soybean meal rations with and without rumensin added.

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[1]Experiment conducted at Panhandle State University, Goodwell.
[2]Oklahoma State University, Stillwater.
[3]Panhandle State University, Goodwell.

Materials and Methods

One-hundred sixty Hereford, Angus, and exotic crossbred steers were allocated by weight and breed to 20 pens of eight head each. Cattle had grazed wheat pasture, then were maintained for four days on a 40 percent silage ration prior to the beginning of the experiment. Cattle were shrunk overnight and weighed at the start of the trial. Interval weights were obtained while on full feed at 28 to 30-day intervals. Final weight was calculated from hot carcass weight assuming a constant dressing percentage of 62 percent.

Routine feedlot vaccinations, and 30 mg. DES implants were administered four days before the starting date. All steers were implanted with Synovex S on day 84 of the experiment. Rations used are listed in Table 1. All rations provided 0.45 percent calcium, 0.3 percent phosphorous, and 0.60 percent potassium. No antibiotic was fed.

Rumen fluid samples were collected for volatile fatty acid and ammonia analysis on days 56 and 114 of the experiment. At slaughter, livers were scored and carcass parameters measured. Statistics were calculated on pen means except for the comparison of rate of gain to steer weight, which was calculated from interval gains with steers grouped into 100 pound increments of average body weight with a 5 percent pencil shrink.

Results and Discussions

Protein Effects

Daily gains were depressed at the lower protein level, especially early in the experiment (Table 2). Gain response to the highest protein level was apparent early in the trial. Up to 750 pounds, (Figure 1) higher protein levels produced more rapid gains. Above this weight, steers in the lower protein groups made some "compensatory" weight gains. But this compensation was

Table 1. Ration composition (dry matter basis)

	Rations			
Ingredient	**9.5**	**10.3**	**11.2**	**12.3**
Corn, whole shelled, %	92.3	89.8	87.3	84.0
Cottonseed hulls, %	5.0	5.0	5.0	5.0
Alfalfa, dehy grnd, %	1.0	1.0	1.0	1.0
Soybean meal, %	---	2.61	5.15	8.58
Poly phos, %	0.04	---	---	---
Calcium carbonate, %	1.05	1.05	1.03	1.00
Potassium chloride, %	0.33	0.24	0.15	0.03
Salt, %	0.30	0.30	0.30	0.30
Trace mineral, ppm	125	125	125	125
Vitamin A, 10,000 Iu/g, ppm	150	150	150	150
Crude Protein (determined)	9.46	10.33	11.23	12.34
Monensin (assay) ppm	0/31	0/31	1/52	3/34

Table 2. Performance and carcass characteristics across protein levels

Item	Ration protein 9.5	10.3	11.2	12.3
Daily gain, lb.				
0-30 days	3.38	3.56	4.42	4.62
0-155 days	3.16[a]	3.29[b]	3.27[b]	3.38[b]
Daily feed, lb.				
0-155 days	17. [ab]	18.1[a]	17.5[b]	17.9[ab]
Feed/gain				
0-155 days	5.61[a]	5.52[ab]	5.34[b]	5.30[b]
Carcass weight, lb.	661	671	661	684
Liver score[1]	0.25	0.47	0.50	0.50
Kidney, heart, pelvic fat, %	2.9	2.9	3.0	2.9
Marbling score[2]	15.8	16.8	17.0	16.9
Backfat, inches	0.61	0.62	0.66	0.63
Ribeye area	12.1	12.4	12.3	12.0
Yield grade[3]	3.3[a]	3.3[a]	3.4[ab]	3.6[b]
Rumen ammonia, mg/dl	4.8	7.3	7.9	12.7
Rumen acetate, molar %	51.0	48.0	47.4	49.8
Rumen propionate, molar %	42.0	45.3	47.2	44.2
Total, m moles/ml.	82.3	80.7	82.2	84.2

[1]0 = none, 1 = one small abscess, 2 = two or three small abscesses and 3 = many small or one or more large abscess.
[2]15 = small+, 16 = modest-, 17 = modest, 18 = modest+, etc.
[a,b]Means with different superscripts differ statistically (P<.10).

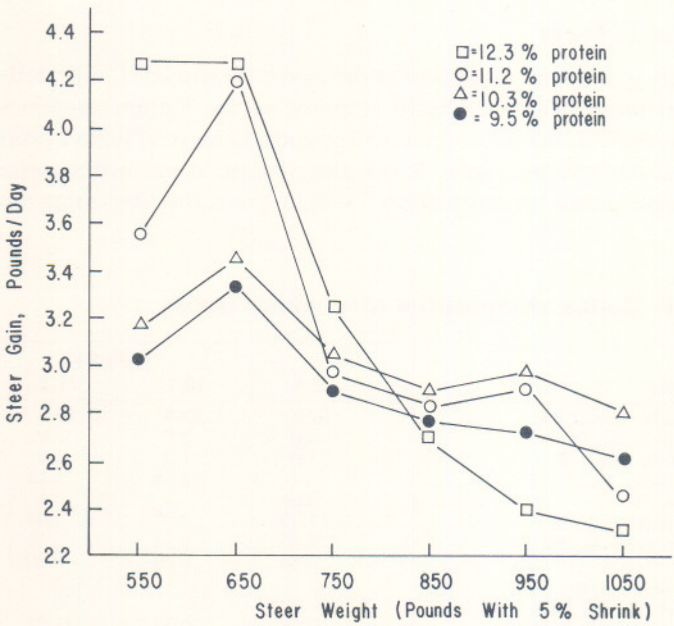

Figure 1. Steer gains at different weights.

limited with the lowest protein ration. Results suggest that steer weight and background may influence response to protein. Young calves will readily respond to protein levels up to 12 percent in whole shelled corn rations. Above 850 pounds, background matters. If steers are to make compensatory gain, moderate protein levels (10.3 in this trial) are needed. If steers are well fed below 700 pounds, no supplemental protein with corn gain (9.5 percent protein) may be needed.

Steers fed higher protein levels tended to have greater marbling, thicker backfat, and higher yield grades. Rumen ammonia concentrations increased with protein level as did propionate to acetate ratio. This suggests that higher protein levels may alter ruminal acid ratios in a manner similar to added rumensin.

Rumensin Effects

Gains (Table 3) were not altered by rumensin addition, but feed intake was decreased by about 0.7 pounds per day which improved feed efficiency by 5 percent. Incidence of liver abscesses was more than doubled by rumensin feeding, and yield grade was depressed slightly. Rumen ammonia was slightly lower with added rumensin, possibly reflecting decreased protein loss in the rumen. Decreased acetate, increased propionate, and slightly lower total acid levels were noted with added rumensin, as is commonly observed.

Rumensin by Protein Interaction

At lower protein levels, rumensin had little affect on feed intake, but improved rate of gain and feed efficiency. At higher protein levels, feed intake and gains were both reduced with added rumensin (Figure 2). So overall feed efficiency improvement due to rumensin decreased as protein levels increased. Improvements in feed efficiency with rumensin were four, ten, five and -two percent at protein levels of 9.5, 10.3, 11.2, and 12.3 percent. Metabolizable

Table 3. Rumensin influence on steer performance

Item	Control	Rumensin
Daily gain, lb.		
0-30 days	3.97	4.02
0-155 days	3.26	3.29
Daily feed, lb.	18.2[a]	17.5[b]
Feed/gain	5.58[a]	5.31[b]
Carcass weight	673	670
Liver score	0.21[a]	0.59[b]
Yield grade	3.55[a]	3.42[b]
Rumen ammonia, mg./dl	9.4	7.9
Rumen acetate, molar %	50.2	48.8
Rumen propionate, molar%	42.8	45.1
Total, mmoles/ml.	84.2	80.4

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

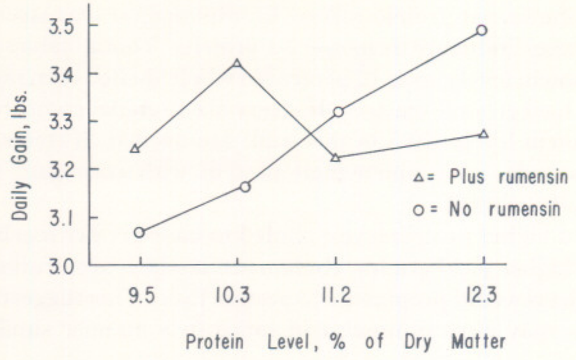

Figure 2. Steer gains with different protein levels with or without rumensin.

energy, calculated from the California Net Energy equation for the four protein and two rumensin levels, are shown in Figure 3. Energy availability was improved as protein level increased without rumensin feeding, but energy availability remained unaffected by protein level when rumensin was added.

Rates of gain were increased most by rumensin when intestinal protein was marginally deficient, during the compensatory gain phase (900-1000 pounds) with the 9.5 percent protein cattle, and the earlier growth period (from 600 to 900 pounds) for the 10.3 percent protein cattle. At the 12.3 percent level, added rumensin reduced rate of gain for steers from 700 to 1100 pounds. Highly elevated protein levels have been shown to depress intakes and gains of steers. Overall, rumensin may spare protein and appears most effective at marginal protein levels.

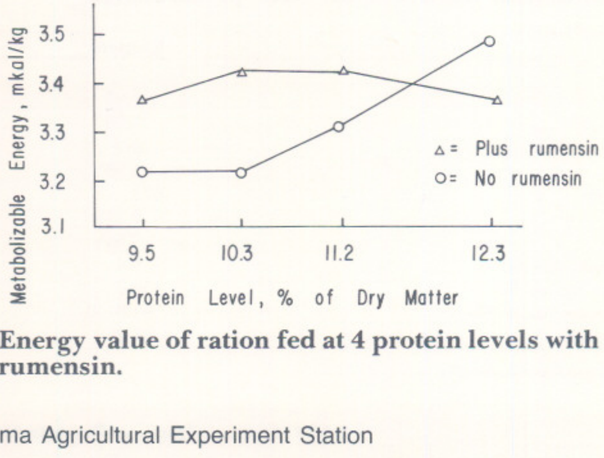

Figure 3. Energy value of ration fed at 4 protein levels with or without rumensin.

References:

1. Martin, Jerry, *et al.* 1976. Okla. Ag. Exp. Sta. Res. Rept-96, p. 87.
2. Elanco, 1977. Rumensin-Protein Seminar, Jan 12, 1977, Indianapolis, Ind.

Protein Sources and Rumensin for Feedlot Steers[1]

J. J. Martin[3], F. N. Owens[2], D. R. Gill[2] and J. H. Thornton[2]

Story in Brief

Thirty-two steers initially weighing 564 pounds were fed whole shelled corn rations containing 11.3 percent protein with all supplemental protein from either soybean meal or urea, and with or without rumensin added. After 155 days, steers were slaughtered and carcasses were evaluated. Daily gains and feed intakes were both five percent higher for urea-fed steers, so feed efficiencies did not differ. Rumensin reduced gain by about two percent and intake by five percent, improving feed efficiency by five percent. Carcasses from steers fed urea were slightly heavier, and yield grades were slightly higher than from steers fed soybean meal.

Introduction

Least cost formulation of feedlot rations often includes urea when soybean meal prices are expensive relative to cereal grains, but urea levels above 0.75 percent of the ration are commonly avoided, especially with high moisture feeds. Animal performance from rations having more urea is often substandard. The advent of rumensin as a feed additive improving feed efficiency and possibly sparing protein suggests that rumensin may prove more beneficial with urea based rations.

The objective of this experiment was to examine the influence and interactions of protein sources (urea vs. soybean meal), and rumensin on steer growth and performance with an 11.3 percent protein shelled-corn ration.

[1]Experiment conducted at Panhandle State University, Goodwell.
[2]Oklahoma State University, Stillwater.
[3]Panhandle State University, Goodwell.

Materials and Methods

Procedures duplicated those presented in "Protein Levels and Rumensin for Feedlot Steers" by Gill *et al.* (1977) also in this publication. Ration compositions are in Table 1.

Results and Discussion

Protein Source

Daily gains and feed intakes (Table 2) were 5 percent greater with urea than soybean meal supplements; however efficiencies did not differ.

Rumensin Addition

Rumensin decreased intake by six percent, and improved efficiency by five percent in this trial. Liver abscess was more than tripled with monensin feeding, but carcass values were unchanged.

Protein Source by Rumensin Interaction

Feed consumption was depressed over 40 percent more by rumensin addition to the soybean meal than to the urea supplemented ration. Consequently, rate of gain was depressed slightly with the rumensin-soy combination. Feed efficiency improvements by rumensin addition, however, were equal (4.7 vs. 5.1 percent) with the two protein sources. The combination of rumensin and soybean meal caused the highest incidence of abscesses as well as the highest degree of marbling in the experiment. No detrimental effects of feeding urea plus rumensin were apparent.

Table 1. Ration composition (dry matter basis)

	Rations	
Ingredient	**Soy**	**Urea**
Corn, whole shelled %	87.3	91.5
Cottonseed hulls, %	5.0	5.0
Alfalfa, dehy, grnd, %	1.0	1.0
Soybean meal, %	5.15	---
Urea, %	---	0.75
Poly Phos, %	---	0.05
Calcium carbonate, %	1.03	1.04
Potassium chloride, %	0.15	0.34
Salt, %	0.30	0.30
Trace mineral, ppm	125	125
Vitamin A, 10,000 Iu/g, ppm	150	150
Monensin, 30 g/lb, ppm	0/500	0/500
Crude protein (determined)	11.23	11.38
Monensin (assay), ppm, 4 rations	1;52	1;15

Table 2. Protein sources and rumensin affects on performance and carcass characteristics

	Soybean meal	Urea	Control	Rumensin
Daily gain, lb.	3.27[a]	3.44[b]	3.38	3.33
Feed intake, lb.	17.5[a]	18.4[b]	18.5[b]	17.4[a]
Feed/gain	5.34	5.37	5.48[a]	5.22[b]
Metabolizable energy Kcd./Kg.	3.37	3.37	3.31	3.43
Carcass weight, lb.	661	680	675	667
Liver abscess[1]	0.50	0.28	0.18	0.59
Kidney, heart, and pelvic fat, %	3.0	3.0	3.0	3.0
Marbling score[2]	17.0	16.8	17.0	16.8
Backfat, in.	0.66	0.74	0.75	0.66
Rib eye area, sq. in.	12.3	11.9	12.2	12.0
Yield grade[3]	3.4	3.8	3.6	3.5

[ab]Means with different superscripts differ statistically (P<.10).
[1]0=None, 1=one small abscess, 2=two or three small abscesses and 3=many small or one or more large abscesses.
[2]15=small +, 16=modest-, 17=modest, 18=modest +, etc.
[3]1=highest and 5=lowest.

In conclusion, urea supplementation of whole shelled-corn ration in this experiment gave steer performance at least equivalent to that from soybean meal supplementation. No intake depression with urea-dry corn rations was apparent as had been observed with the urea-high moisture corn combination previously (Martin, *et al.*, 1976). Rumensin addition improved efficiency of energy use about five percent, equally with both rations.

References:

1. Gill, Donald, *et al.* 1977. Elsewhere in this Misc. Publ.
2. Martin, Jerry, *et al.* 1976. Okla. Ag. Exp. Sta. Res. Rept-96, p. 87.

Protein Withdrawal for Feedlot Steers[1]

F. N. Owens[2], D. R. Gill[2], J. J. Martin[3] and J. H. Thornton[2]

Story in Brief

Seventy-two 759 pound steers were fed shelled corn-soybean meal supplemented rations for 97 days. All steers were fed rumensin. Three pens of steers were fed 11.2 percent protein, three pens at 10.3 percent protein for the entire trial, and three pens at 10.3 percent protein for 28 days (to 835 pounds) after which soybean meal was removed from the supplement to form a 9.5 percent protein ration. Protein reduction to 10.3 percent protein at 760 pounds or 9.5 percent at 835 pounds did not alter performance or carcass characteristics. Feed intake was not reduced by protein reduction in either group. Results suggest that the protein requirement for steers fed whole shelled corn is below 10.3 percent for steers over 760, and may be below 9.5 percent at 835 pounds if steers have gained well at lighter weights. The final drop reduced feed efficiency slightly, however.

Introduction

The amount of protein required for growing steers depends upon: 1) the intestinal amino acid supply relative to the amount of protein growth occurring, which in turn depends upon age, breed, type, and growth rate, and 2) the ammonia need for bacteria in the rumen, which depends on energy level of the ration and amount of protein degraded in and urea recycled to the rumen. Protein requirements decline with maturation as fat rather than muscle is being produced. Consequently, reduced protein supplementation is needed for animals over a certain weight. Some research (Preston and Cahill, 1972) has suggested that all supplemental protein may be deleted from corn based rations for steers over 750 or 850 pounds.

The objective of this experiment was to determine animal response to reduction of protein level from 11.2 to 10.3 percent at 750 pounds and a second reduction to 9.5 percent at 835 pounds.

Materials and Methods

The three rations used in this experiment are the rumensin supplemented 9.5, 10.3, and 11.2 percent protein rations described in the protein level rumensin study (Gill *et al.*) reported on page 51 in this publication. Steers

[1]Experiment conducted at Panhandle State University, Goodwell.
[2]Oklahoma State University, Stillwater.
[3]Panhandle State University, Goodwell.

were handled in a manner identical to that trial, and were all fed the 11.2 percent protein ration for 58 days until the start of this experiment. Three pens of cattle (24 steers) remained on this ration for the remaining 97 days, whereas, the protein level for six pens (48 steers) was dropped to 10.3 percent at the start of this trial, three pens of which were reduced a second time to 9.5 percent protein at 835 pounds. Performance and carcass measurements duplicated those of the protein level study.

Results and Discussion

Reducing protein level in the whole shelled corn-soybean meal ration from 11.2 to 10.3 percent at 750 pounds had no adverse influence on performance or carcass characteristics (Table 1). Gain and feed efficiencies were slightly improved by the reduction, and rather than feed intake reduction, as has been commonly noted with protein restriction (Thomas, *et al.*, 1976), feed intake was slightly higher for pens of cattle fed lower levels of protein.

The second protein drop, deleting all supplemental protein reduced gain and increased feed intake slightly, and feed efficiency was slightly poorer. This

Table 1. Steer response to protein reduction

	Protein level		
Item	**11.2**	**10.3**	**10.3-9.5**
Initial weight, lb.	759	752	766
28 day weight, lb.	835	827	835
Final weight, lb.	1059	1070	1069
Daily gain, lb.			
0-28	2.70	2.69	2.49
28-97	3.26	3.52	3.39
0-97	3.09	3.28	3.12
Daily feed, lb.			
0-28	16.6	17.0	17.5
28-97	17.3	17.6	18.0
0-97	17.1	17.4	17.8
Feed/gain			
0-28	6.20	6.34	7.15
28-97	5.31	5.02	5.31
0-97	5.52	5.33	5.72
Carcass weight, lb.	657.0	663.8	662.8
Liver abscess incidence	0.54	0.50	0.75
Kidney, heart, pelvic fat, %	2.92	2.90	2.94
Marbling score	15.96	17.29	16.42
Backfat, inches	0.63	0.65	0.61
Ribeye area, sq. in.	12.03	11.99	11.88
Yield grade	3.38	3.47	3.41

drop increased by 20 pounds the feed dry matter needed for 100 pounds of gain. No other adverse affects were apparent.

Results indicate that with whole-corn rations, a 10.3 percent protein level is adequate for steers over 750 pounds. This is below the 10.5 to 10.9 percent recommended by the NRC (1976). The 9.5 percent protein may be slightly deficient for steers from 835 to 1070 pounds. The NRC currently recommends 10.0 percent protein for such steers.

Results also suggest that feed efficiency may respond to protein deficiency before gains are severely depressed. This means that full effects of protein deficiency may not be apparent until total feed costs are tabulated. Consequently, protein deficiency may be a costly problem which is difficult to detect but simple to prevent by feed analysis. Whether dietary protein requirements for steers fed high moisture corn-corn silage rations would differ from that for steers fed whole shelled corn remains to be determined. As corn varies in protein content, protein content should be analyzed to be safe before deletion. Also additives other than protein need to be continually fed and not deleted when protein level is reduced.

References:

1. Preston, R. L. and V. R. Cahill. 1972. Beef Cattle Wooster, Ohio.
3. Thomas, V. M. 1976. J. Animal Sci. 43:850.
4. N.R.C. 1976. Nutrient Requirements for Beef Cattle. National Academy of Sciences, Washington, D.C.

Rumensin Effects on Energy Losses at Three Fiber Levels

J. H. Thornton and F. N. Owens

Story in Brief

The effect of rumensin on energy losses via feces, urine, heat, and methane was measured in digestion and gas collection trials with six steers. Rations contained 12, 27, and 40 percent fiber. Rumensin had no effect on loss of energy in urine, feces or heat, but energy loss as methane was depressed more than 10 percent at all three fiber levels. Reduction in methane losses of this magnitude can explain half or more of the improvement in feed efficiency expected from rumensin feeding. Similar effects at different fiber levels indicate rumensin will prove beneficial with a wide range of feedstuffs. As methane loss is a higher percent of net energy with high roughage rations than with high concentrate rations, monensin may prove more useful with higher roughage rations than with high concentrate rations.

Introduction

Data from numerous trials have shown that rumensin addition to feedlot rations improves efficiency of feed use. Improvement in feed efficiency could result from decreased energy losses from one or more of four areas: 1) fecal losses, 2) urinary losses, 3) gaseous products of digestion (methane), and 4) heat production.

The objectives of this study were to determine the effect of rumensin on energy losses in feces, in urine, as heat production, and as methane. Three trials were conducted with rations containing different levels of fiber to determine if rumensin action was influenced by type of feedstuff.

Materials and Methods

Six steers were used in a series of digestion and respiration gas collection trials. Cottonseed hulls and soybean meal were varied to achieve 12, 27, and 40 percent fiber, and approximately 12.5 percent crude protein in the rations. Steers received nine lb./day when fed the 12 percent fiber ration, and 12 lb./day when fed the 27 and 40 percent fiber rations. Steers were fed once daily, and rumensin, when fed, was mixed with the ration at feeding time at the rate of 200 mg. per steer daily.

Digestion trials were conducted in three periods with one ration fed to all six steers, and rumensin to three of the six steers. Following a nine day adjustment period, feces and urine were collected for five days.

Respiration gas trials used face masks, and expired gas was analyzed hourly during six-hour trials, and bi-hourly during 24-hour trials. Two steers were used in each trial with one receiving rumensin. Six trials were conducted with animals receiving the 27 percent fiber diet, and three trials with animals receiving 12 and 40 percent fiber diets. In all trials, gases were monitored for approximately six hours beginning immediately following consumption of the daily ration, and in three trials, one at each fiber level, gases were monitored for 24 hours.

Results and Discussion

Fecal energy losses tended to be less when rumensin was fed, as shown by the slightly higher digestible energy values (Table 1). Urinary energy losses (Table 2) were not changed by rumensin feeding. Likewise, heat production (Table 3), calculated from carbon dioxide and methane production, and oxygen consumption, was not affected by rumensin feeding. However,

Table 1. Digestible energy

Fiber	Control		Monensin	Sig.
	--------	%	--------	
Low	78.7		79.6	NS
Medium	65.8		66.8	NS
High	61.1		63.4	NS

Table 2. Urinary energy, percent of gross

Fiber	Control		Monensin	Sig.
	--------	%	--------	
Low	3.7		3.8	NS
Medium	2.5		2.3	NS
High	2.9		3.3	NS

Table 3 Heat production

Fiber	Control		Monensin	Sig.
	---	Kcal/hr $Kg^{-.75}$	---	
Low	6.02		5.57	NS
Medium	5.88		6.25	NS
High	6.18		5.94	NS

methane production during the six hours after feeding (Table 4) was reduced considerably when rumensin was added to each of the three rations. Depression in methane production from rumensin diminished over the 24-hour period between feedings (Figure 1). This effect was similar at all three fiber levels. Although higher fiber levels reduced energy digestibility and increased methane production, rumensin effects were similar at all three fiber levels used in this study. Thus rumensin benefits should be exhibited across a wide range of feedstuffs.

To place methane production in perspective, the energy value of methane produced when rumensin was not fed averaged 7.9 percent of the gross energy intake for the three fiber levels. Rumensin decreased this energy loss by 10.7 percent, to 7.0 percent of gross energy intake over the 24-hour period. Energy savings of this magnitude would increase net energy values of rations sufficiently to cause a 5.5 percent improvement in feed efficiency for animals gaining two lb./day or a 2.2 percent boost for animals gaining three lb./day. If

Table 4. Methane production

Fiber	Control		Monensin	Sig.
	--------	l/hr	--------	
Low	7.69		6.44	P<.10
Medium	8.99		7.50	P<.05
High	10.15		7.55	P<.05

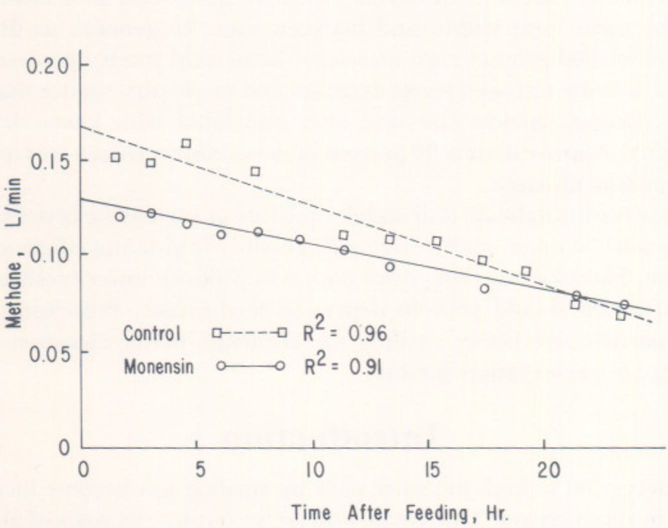

Figure 1. Effect of monensin and time after feeding on CH_4 production by steers fed a 27 percent fiber diet.

these calculations had been based upon the methane reductions witnessed the first six hours following feeding, instead of over the 24-hour period, energy savings would boost feed efficiency approximately twice that stated above. Thus energy conservation from reduced methane production can explain much of the improvement in animal performance reported from feeding of rumensin.

Chemical Characterization of Ensiled Ground High Moisture Corn Grain

J. H. Thornton, F. N. Owens, D. E. Williams and M. Arnold

Story in Brief

Analysis of ensiled corn samples from 12 horizontal silos indicate large differences exist both within and between silos. In general, as dry matter content of ensiled ground corn increases, lactic acid levels decrease and pH increases, soluble nitrogen levels decrease and *in vitro* dry matter digestibility declines. Larger particle size was also associated with lower dry matter digestibility. Approximately 90 percent of the soluble nitrogen was in the form of non-protein nitrogen.

These results indicate that higher moisture grain may be better preserved and may also be more readily digested, possibly improving efficiency of feed utilization. However, ensiling drier corn will produce lower levels of soluble nitrogen, which should prevent depressed feed intake. Processing grain to smaller particle size before ensiling should insure better digestion and may also improve preservation quality.

Introduction

Preservation of high moisture corn by ensiling has become increasingly popular in recent years. This trend will likely continue as costs of alternative methods of grain preservation, such as drying with fossil fuels, continue to increase. Some producers are hesitant to adopt high moisture grain storage because of variation in quality of the product and problems associated with feeding high moisture grain. Such worries could be reduced if factors affecting quality and subsequent animal performance were better described.

The purpose of this study was to characterize ensiled ground high moisture corn grain preserved in large horizontal silos.

Materials and Methods

Thirty-one samples of ensiled ground high moisture corn from the 1975 crop year, were obtained during early winter 1976 from 12 horizontal silos located on the High Plains region of Oklahoma and Kansas. Samples were analyzed for dry matter, total nitrogen, soluble nitrogen, soluble non-protein nitrogen, pH, lactic acid, acetic acid, particle size, and *in vitro* dry matter digestibility.

Results and Discussion

Ensiled corn in some of the individual silos sampled was quite uniform in appearance and analysis of samples from different areas in these silos revealed very similar characteristics. In contrast to this, some silos had layers of material differing in appearance, and samples from different layers revealed strikingly different chemical compositions. Differences within certain silos were as great as differences between silos.

Rather than present data by sample or silo, the relationship between variables measured are shown by graphing analyses against moisture content or particle size of the samples taken. Table 1 shows the relationships of all measurements.

Dry matter is related rather closely to several variables, as indicated by the asterisks. Dry matter is one of two factors which can be altered at ensiling time. For this reason, plots of these relationships are shown. Figures 1 and 2 show that as grain dry matter decreases, the pH of the sample declines and higher lactic acid values are present. Figure 3 indicates that soluble nitrogen levels decrease as grain dry matter increases. The relationship between soluble nitrogen and soluble non-protein nitrogen (Figure 4) is extremely close with approximately 91 percent of the soluble nitrogen being non-protein nitrogen. *In vitro* dry matter disappearance of unground samples (Figure 5) reveals that drier grain is less readily digested in the rumen.

The other variable which can be modified when grain is placed in silos is particle size. Figure 6 shows that ensiled grain with smaller particle size is more easily digested.

Since high levels of lactic acid and low pH are thought to be indicative of high quality silage, lower dry matter (higher moisture) grain and finer particle size would be expected to produce the best quality ensiled grain. However, such material would be expected to produce higher levels of soluble nitrogen,

Table 1. Relationships between characteristics of ensiled corn grain[1]

	D.M.	pH	Lactic Acid	Acetic Acid	Soluble N	Soluble NPN	Pepsin Insol. N	IVDMD 21 HR.	IVDMD 48 HR.
pH	.65**	------	------	------	------	------	------	------	------
Lactic Acid	-.69**	-.87**	------	------	------	------	------	------	------
Acetic Acid	-.42*	-.11	.32	------	------	------	------	------	------
Soluble N	-.81**	-.80**	.71**	.21	------	------	------	------	------
Soluble NPN	-.79**	-.74**	.67**	.29	.98**	------	------	------	------
Pepsin Insol N	.32	.36*	-.29	-.07	-.61**	-.57**	------	------	------
IVDMD, 21 HR.	-.62**	-.31	.34	.40*	.35	.36*	-.07	------	------
IVDMD, 48 HR.	-18	-.03	.18	.20	-.15	-.15	.18	.37*	------
Particle size	.44*	.52**	-.49**	-.09	-.38*	-.38*	-.01	-.51*	-.43*

[1]Higher values represent closer relationships.
*P<.05, **P<.01

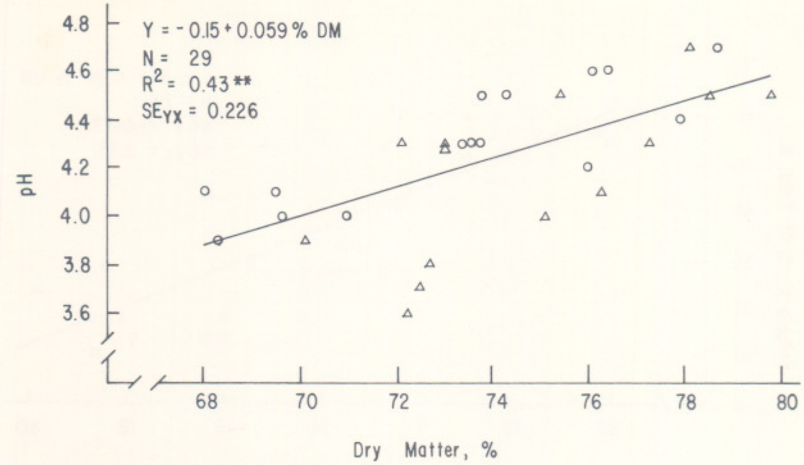

Figure 1. Relationship between percent dry matter and pH.

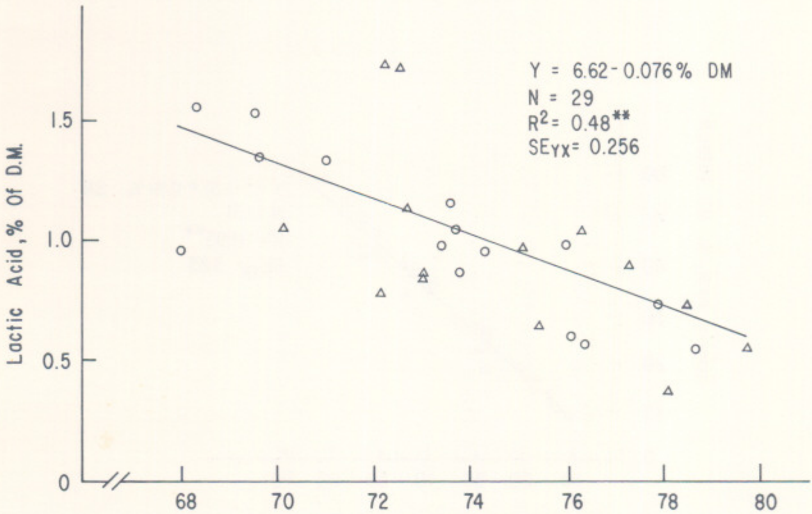

Figure 2. Relationship between dry matter and lactic acid.

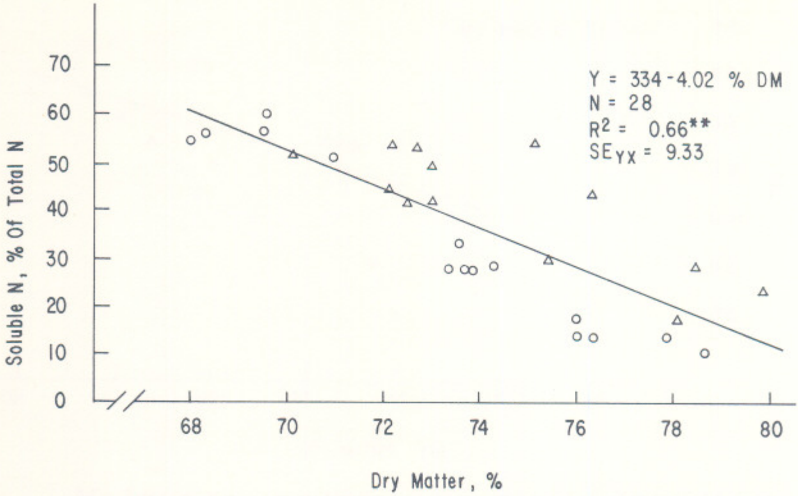

Figure 3. Relationship between dry matter and soluble nitrogen.

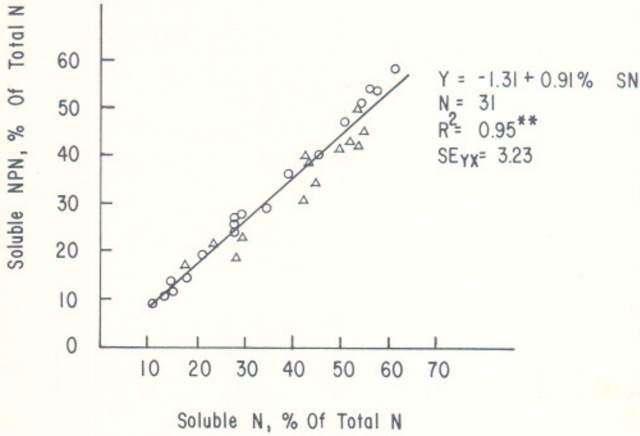

Figure 4. Relationship between soluble nitrogen and soluble NPN.

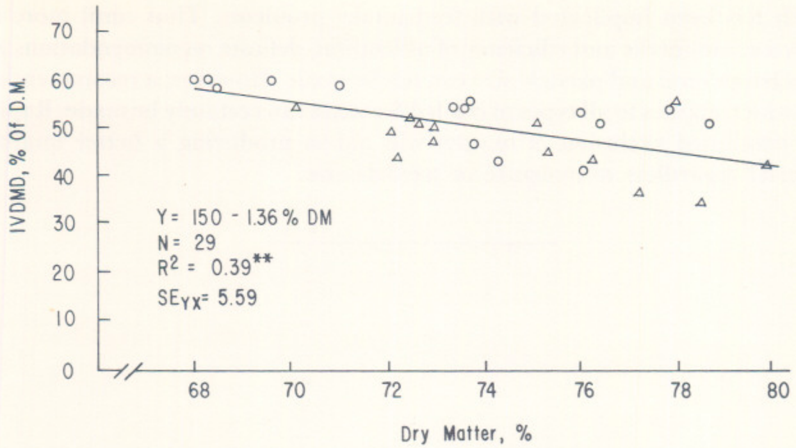

Figure 5. Relationship between dry matter and *in vitro* D.M. disappearance in 21 hrs. (unground).

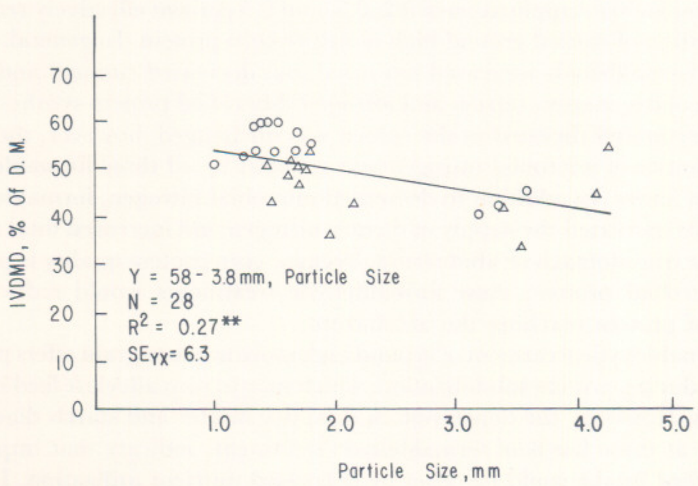

Figure 6. Relationship between geometric mean particle size and *in vitro* D.M. disappearance in 21 hrs. (unground).

which has been implicated with feed intake problems. Thus until more is known about intake and efficiency of utilization, definite recommendations as to moisture level and particle size can not be made. However, a recommendation which applies to all types of ensiled material can certainly be made. Rapid and continued exclusion of oxygen will aid in producing a better quality material regardless of moisture or particle size.

Fermentation and Digestion of Formaldehyde Treated Ensiled High Moisture Corn Grain

J. H. Thornton, F. N. Owens, D. E. Williams and E. C. Prigge

Story in Brief

Formaldehyde application of 0.2, 0.3, and 0.5 percent effectively reduced solubilization of ensiled ground high moisture corn protein. In general, these levels of formaldehyde increased intestinal, but decreased ruminal and total digestion of dry matter, starch, and nitrogen. Microbial protein synthesis per unit of dry matter digested in the rumen was unchanged, however, the total daily quantity of microbial nitrogen was reduced by all three formaldehyde treatment levels. In addition to decreased microbial nitrogen, formaldehyde treatments increased the supply of dietary nitrogen and increased total nitrogen to the true stomach or abomasum. Because corn protein quality is poorer than microbial protein, these formaldehyde treatments would reduce the quality of protein reaching the abomasum.

Formaldehyde treatment of ground high moisture corn grain offers potential for reducing protein solubilization, which may in turn alleviate feed intake problems. However, the depression in total dry matter and starch digestion observed at these levels of formaldehyde treatments indicate that improvement in feed intake could be offset by decreased nutrient utilization. Levels above 0.2 percent are useless. If lower levels of formaldehyde will prevent protein solubilization without decreasing total nutrient utilization, such

treatment may prove useful, but this remains to be demonstrated before its use could be recommended.

Introduction

Several economic factors have advanced the practice of harvesting grain at moisture levels too high for storage without drying or preserving. Of the methods for preserving high moisture grain, ensiling is both economical and acceptable for grain destined to be fed to livestock. One problem associated with feeding ensiled feeds, depressed feed consumption, appears related to the high levels of soluble nitrogen often formed in ensiled feedstuffs. Characterization of ensiled ground high moisture corn grain from large horizontal silos located in feedlots on the High Plains Region of Oklahoma and Kansas has revealed soluble nitrogen levels as high as 70 percent of total nitrogen (Thornton *et al.*, 1976).

Since formaldehyde insolubilizes protein, treating high moisture grains with formaldehyde could reduce soluble nitrogen levels, and in turn improve feed consumption. However, formaldehyde treatment would also inhibit digestion; thus benefits of such treatment would depend upon ruminal and total nitrogen and energy utilization.

The objectives of this study were to determine the effects of formaldehyde treatment of ensiled high moisture corn grain on: 1) solubilization of corn nitrogen during fermentation, 2) site and extent of dry matter, starch and nitrogen digestion, and nitrogen retention in steers, and 3) quantity of microbial protein synthesis.

Materials and Methods

A formyl solution, containing 40 percent formaldehyde, was applied to ground high moisture corn grain to supply 0.2, 0.3 and 0.5 percent formaldehyde on a wet basis. This material, plus untreated material, was packed in 55 gallon metal drums lined with plastic bags, sealed, and stored four months before feeding to allow fermentation and solubilization of the corn protein. The ensiled corn grain was fed to four ruminally and abomasally fistulated steers in an arrangement of treatments so that each steer received each treatment. The rations (Table 1) provided 11.6 percent crude protein, and were fed hourly with mechanized feeders at a level of 9.25 pounds ration dry matter daily. Polyethylene glycol (PEG) and chromic oxide were included as nondigestible markers and used for calculating ruminal digestion.

Following a ten-day adjustment period, total urine and feces were collected for four days followed by a two-day (two samples/day) rumen and abomasal sample collection. Ensiled corn was analyzed for dry matter, total, and soluble nitrogen. Rations were analyzed for dry matter, starch, total nitrogen, lignin, and PEG. Rumen samples were analyzed for ammonia.

Table 1. Ration composition, dry matter basis

Ingredient	Percent
Ensiled HMC Grain	80
Cottonseed hulls	12
Soybean meal	3.6
Dry corn	2.3
Urea	0.6
Calcium carbonate	.8
Dicalcium phosphate	.35
Trace mineral salt	.35
Potassium chloride	.25
Polyethylene glycol	1.25
Chromic oxide	0.5

Abomasal samples were analyzed for dry matter, starch, total nitrogen, ribonucleic acids (RNA), lignin, and PEG. Urine nitrogen and fecal dry matter, starch, and nitrogen analyses were made.

Results and Discussion

Soluble nitrogen was reduced from 16.2 percent to 4, 3, and 2 percent by 0.2, 0.3, and 0.5 percent formaldehyde treatments. The soluble nitrogen of the control corn (16.2 percent) was unusually low for material containing 27 percent moisture. Based upon samples from large horizontal silos (page 56 this publication) soluble nitrogen in the range of 30 to 50 percent is typical of ensiled ground corn of this moisture level. Whether silo size, packing, storage time or other factors caused this discrepancy is not certain. Nevertheless, all formaldehyde treatments reduced protein solubilization.

All three formaldehyde treatments reduced ruminal dry matter disappearance (lower line, Figure 1), and total dry matter disappearance (upper line). Dry matter disappearance postruminally (the difference between the two curves) was increased at a level of 0.3 percent formaldehyde.

Ruminal starch digestion (Figure 1) was significantly reduced by 0.2 and 0.3 percent formaldehyde, and post-ruminal digestion was increased by 0.3 percent formaldehyde. Approximately five times more starch was recovered in

Table 2. Ensiled ground high moisture corn grain analysis

Item	Formaldehyde level, percent 0	0.2	0.3	0.5
Dry matter, %	72.9	72.3	73.5	73.0
Crude protein, %	9.2	9.4	9.1	9.1
Sol. N, % of total	16.2	4.0	3.0	2.0

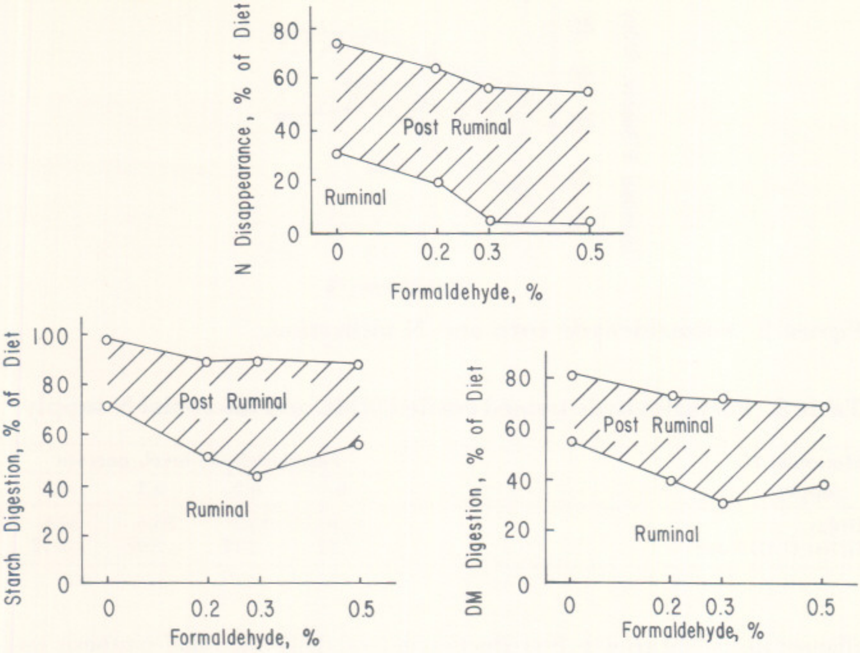

Figure 1. Effect of formaldehyde treated ensiled corn grain on disappearance of dry matter, starch and nitrogen at the abomasum (ruminal) and at feces (total) in steer metabolism studies.

feces from steers fed the formaldehyde treated grain (2.3, 11, 10, and 12 percent of dietary starch for 0, 0.2, 0.3, and .5 percent formaldehyde).

Nitrogen disappearance (Figure 1) was reduced ruminally by 0.3 percent and 0.5 percent formaldehyde, but unchanged post-ruminally. Total tract (upper line) nitrogen disappearance was less with all three formaldehyde treatments. The decreased nitrogen disappearance corresponds to the increased fecal losses (Figure 2). Urinary losses were less with 0.3 percent formaldehyde, however nitrogen retention did not differ greatly between treatments.

Estimates of microbial protein synthesis in the rumen (Table 3) were calculated from microbial protein concentration in abomasal digesta (calculated from RNA), and abomasal passage rate (calculated from PEG). Total microbial nitrogen reaching the abomasum daily was reduced from 43.6 to 25.6 gm./day by formaldehyde treatment. However, microbial nitrogen produced per 100 gm. dry matter digested in the rumen (1.97 to 2.17 gm./100 DM digested) were similar for all treatment levels. Rumen ammonia levels (13, 10, 8, and 7 mg./100 ml. rumen fluid) should have provided adequate nitrogen for

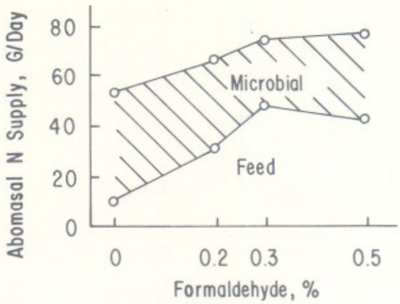

Figure 2. Formaldehyde corn and N utilization.

Table 3. Formaldehyde treated ensiled HMC and microbial N supply

Microbial N supply	Formaldehyde level, percent			
	0	0.2	0.3	0.5
G/day	43.6	35.3	25.6	33.6
G/100 G DM dig.	1.97	2.17	2.02	2.12

efficient microbial growth. So reduction in total daily microbial synthesis was a result of the depression in ruminal dry matter or starch digestion, not reduced efficiency of bacterial growth.

The protein needs of ruminant animals are met from two sources, microbial protein synthesized during rumen fermentation, and feed protein escaping rumen degradation. Figure 3 depicts the relative contributions of microbial nitrogen and total nitrogen at the abomasum. Reduction in microbial nitrogen supply was more than offset by increased bypass of dietary nitrogen following formaldehyde treatment. Unfortunately, such a trade-off would lower the quality of protein available to the animal, since for animals the value

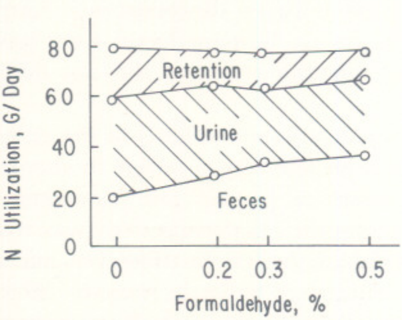

Figure 3. Formaldehyde corn and abomasal N supply.

of microbial protein is higher than corn protein. Consequently such formaldehyde treated corn would prove most useful in rations for animals where quality of protein is less important.

References:

Thornton, J. H. *et al.*, 1976. Okla. Agri. Exp. Sta. MP-96:176

Ensiled Corn Grain Moisture Level and Supplement Protein Source Effects on Feed Intake

J. H. Thornton, F. N. Owens, D. E. Williams, R. P. Lake and R. W. Fent

Story in Brief

Ensiled ground high moisture corn of two moisture levels, 24 and 30 percent and containing 24 and 49 percent of nitrogen in a soluble form was fed with either urea or soybean meal supplements to sixteen 500 pound steers to estimate voluntary intake. Consumption of dry matter from the higher moisture - higher soluble nitrogen grain was 12 percent less than the drier - lower soluble nitrogen grain. Urea reduced intake only slightly (5 percent reduction). This study would indicate that: (1) urea can be satisfactorily fed with ensiled corn rations, and (2) grain intake may be increased by ensiling drier grain, although improvement in animal performance may not correspond to increased intake.

Introduction

Livestockmen feeding ensiled high moisture corn voice two concerns: 1) problems with feed intake, and 2) complications associated with non-protein nitrogen supplements. These two concerns may be inter-related in that a portion of ensiled corn protein is degraded to non-protein nitrogen during storage. Intake depressions in feedlots have been related to high moisture and high nitrogen solubility of corn grain (Sprague and Brenniman, 1969). Although recent work (Prigge *et al.*, 1975) indicated that nitrogen in ensiled corn grain, as well as urea nitrogen additions to ensiled corn, can be efficiently utilized by steers, effects of added urea on feed intake were unclear. Recent work (page 56 this publication) has shown that soluble or non-protein nitrogen is much lower when ensiled corn grain contains less moisture.

The objectives of this study were to determine effects of moisture and soluble nitrogen level of high moisture corn together with supplement protein solubility (urea vs. soybean meal) on feed intake.

Materials and Methods

Ensiled ground high moisture corn grain was obtained from two large horizontal silos, packed in plastic bags (approximately 70 pounds wet material per bag), transported to Stillwater, and stored frozen until fed. The corn was fed with cottonseed hulls and either a urea or soybean meal based supplement (Table 1) to provide 11.5 percent crude protein. Two pens, with two-500 pound steers per pen, received each corn-supplement combination for four weeks. Rations were fed twice daily at levels to allow feed refusals. Records of feed consumption and weight gains were recorded. The ensiled grain was analyzed for dry matter, pH, total and soluble nitrogen, and lactic acid.

Results and Discussions

Ensiled ground high moisture corn grain from silo W (wet) contained 5.7 percent more moisture (Table 2) and over twice as much soluble nitrogen as corn from silo D (dry). Lactic acid was also higher and pH lower in silo W.

Daily intakes (Table 3) and daily gains (Table 4), plus visual observation, indicated animals were gaining well. However, daily intakes of steers

Table 1. Ration composition, Dry matter basis

Ingredient	Supplement (percent)	
	Urea	SBM
Ensiled HMCG	70	70
Cottonseed hulls	14	14
Supplement	16	16
Corn	(7.01)	(2.06)
Urea	(0.98)	--
Soybean meal	--	(6.83)
Alfalfa, 17% CP	(6.00)	(6.00)
Ground limestone	(0.78)	(0.85)
TM salt	(0.30)	(0.30)
Potassium chloride	(0.02)	--
Sodium sulfate	(0.17)	--
Vitamin A & D	+	+

Table 2. Ensiled ground high moisture corn grain analysis

Item	Silo W	Silo D
Dry matter, %	70.4	76.1
Crude Protein, %	10.0	9.6
Sol. N, % of total N	49.4	23.7
pH	4.0	4.6
Lactic acid, %	1.1	0.6

Table 3. Ensiled corn and nitrogen supplement effects on ration consumption by 500 pound steers[1]

	Average daily intake		
Supplement	Silo W	Silo D	Average
	lb/day		
Urea	12.6	13.7	13.2
SBM	12.9	14.9	13.9
Average	12.8[a]	14.3[b]	--

[1]Daily intakes during approximately 2 weeks when feed refusals indicated maximum voluntary intake.
[a,b]Significantly different at $P<.05$.

Table 4. Ensiled corn and nitrogen supplement effects on sixteen day daily gain

	Average daily gain		
Supplement	Silo W	Silo D	Average
	lb/day		
Urea	3.66	3.50	3.58
SBM	3.55	3.55	3.55
Average	3.60	3.52	--

receiving grain from silo W were significantly less than those of steers fed grain from silo D. Intakes were only slightly reduced when urea replaced soybean meal as the source of supplemental nitrogen. Depressions in intake were not reflected by reduced daily gains.

This study indicates feed intake depression occurs when ensiled grain contains the higher levels of moisture, soluble nitrogen and/or acids. Since the addition of soluble nitrogen as urea reduced intake only slightly, and indeed less when added to the higher than the lower soluble nitrogen grain, reduced intake may be attributed to factors other than soluble nitrogen. Although gains were measured over only 16 days, these gains illustrate that intake depression from feeding higher moisture - higher soluble nitrogen grain may not detrimentally affect animal performance. Study of energy availabilty from the two corns is underway. This should determine if intake is reduced simply because more energy is available from corn having a higher moisture content.

References:

1. Prigge, E. C., *et al.* 1975. Okla. Agri. Exp. Sta. MP-94, p. 63.
2. Sprague, J. I. and G. W. Brenniman, 1969. Feedstuffs 46:20.

Nylon Bag Dry Matter Digestion of Corn as Influenced by Particle Size, Steam Flaking and High Moisture Processing

M. L. Galyean, D. G. Wagner and F. N. Owens

Story in Brief

Corn grain was sieved to obtain distinct particle sizes and incubated in nylon bags for varying time periods in the rumen of a mature Holstein steer. In Experiment 1, dry rolled corn sieved to provide sizes of 6.0, 3.0, 1.5, and 0.75 mm. was incubated for two, four, six or eight hours. Dry matter digestion (DMD) (averaged over all time periods) was similar for 6.0 mm. (4.98 percent), and 3.0 mm. (4.38 percent). However, DMD roughly doubled as particle size was halved to 1.5 mm. (9.74 percent), and 0.75 mm. (18.38 percent). Experiment 2 compared steam flaked (SF) and dry ground (DG) corn at 3.0 mm., 1.5 mm., and 0.75 mm. sizes for two, four, six or eight hours. SF had higher DMD within each particle size than DG. An approximate doubling of DMD as size was halved was not observed with SF as with DG. Experiment 3 was concerned with a comparison of ground, ensiled high moisture corn (HM) and DG at 3.0 mm., 1.5 mm., and 0.75 mm. sizes. Both HM and DG increased in DMD as size was reduced; however, HM generally had higher DM valves within each particle size than DG. Particle size also had significant effects on the DMD of corn incubated for 12 or 24 hours, and on DMD of sorghum incubated for two, four, six or eight hours (Experiments 4 and 5, respectively).

This study indicates particle size has an important impact on digestion of processed as well as unprocessed corn, but is probably of greater importance with dry and high moisture, ensiled corn than with steam flaked corn.

Introduction

Particle size or physical form of grain has been demonstrated to be important relative to extent of digestion in cattle. Little is known, however, about the effect of particle size on ruminal digestion of grain. Available information would suggest that grains with greater digestion in the rumen result in improvements in feed efficiency compared to grains of lower ruminal digestion. Since large quantities of processed and unprocessed grains are routinely fed in commercial feedlots, information concerning the relationship of particle size to ruminal digestion may improve our ability to more efficiently produce beef.

Thus, this study was undertaken to investigate the influence of particle size on dry matter digestion (DMD) of unprocessed, steam flaked, and high moisture, ensiled corn, using a nylon bag, ruminal incubation technique. The DMD of sorghum was also considered.

Materials and Methods

Experiment 1

Dry rolled corn, obtained from the university feed mill was sieved through a set of standard sieves. Corn particles retained on screens with openings of 4.0 mm., 2.0 mm., 1.0 mm. and 0.5 mm. were separated to provide four distinct average particle sizes. Average size of the four groups were: 6.0 mm. (range 8.0 mm.-4.0 mm.); 3.0 mm. (range 4.0 mm.-2.0 mm.); 1.5 mm. (range 2.0 mm.-1.0 mm.) and 0.75 mm. (range 1.0 mm.-0.5 mm.). Approximately five grams of each of the four average particle sizes were weighed into 100 mesh nylon cloth bags. Bags were constructed of parachute material, sewn with nylon thread, and were approximately 5 X 12 cm. in size.

Duplicate bags of each size, attached to a nylon cord by fishing swivels, and anchored by an 80 gm lead weight were placed in the rumen of a mature, Holstein steer. Four such cords, one for each incubation period were used with eight bags per cord and incubated for two, four, six or eight hours. This entire procedure was replicated on another day to provide a measure of experimental error. The donor steer was fed a 62.75 percent dry rolled corn diet, *ad libitum* and housed in a slotted floor pen.

All bags were dried at 100°C and weighed prior to inclusion of particle size samples. After incubation, bags were washed under tap water and dried for 48 hours at 65°C followed by 2 to 4 hours at 100°C. Bags were then weighed to determine the percentage of dry matter digested.

Experiment 2

Corn obtained from a commercial feedlot was either steam flaked (atmospheric pressure, 100°C, approximately 20 min.) or left in the whole form. Both steam flaked and whole corn were ground through a 6 mm. screen, and sieved as in Experiment 1. Resulting average particle sizes were 3.0 mm., 1.5

mm., and 0.75 mm. for both steam flaked (SF) and dry ground (DG) corn. Nylon bag procedures described in Experiment 1 were used to compare the DMD of SF and DG.

Experiment 3

Ground, high moisture ensiled corn from a commercial feedlot was sieved to provide sizes of 3.0 mm., 1.5 mm., and 0.75 mm. and compared to DG corn using previously described procedures.

Experiment 4

The four average sizes of corn discussed in Experiment 1 were incubated for either 12 or 24 hours to see if particle size was still important beyond the eight hour periods previously studied. Procedures were equivalent to those described previously.

Experiment 5

Dry rolled sorghum obtained from the university feed mill was sieved as before and incubated in nylon bags for two, four, six or eight hours. Particle sizes used were 3.0 mm., 1.5 mm., and 0.75 mm.

Statistical analysis were conducted on the data from the five experiments, and significant differences between means are denoted as superscripts in the tables.

Results and Discussion

Experiment 1

DMD of the four sizes of dry rolled corn (DR) is given in Table 1. DMD means are reported either average over time (size means) or size (time means). Size means indicate 6.0 mm. (4.98 percent), and 3.0 mm. (4.38 percent) sizes were very similar in DMD; however, DMD increased as size was reduced from 3.0 mm. to 1.5 mm. (9.74 percent), and 0.75 mm. (18.38 percent). This suggests that DMD is approximately doubled as average size is halved from sizes 3.0 mm. and below. Time means show that DMD increased as length of incubation increased from two to eight hours. The magnitude of DMD change

Table 1. Nylon bag dry matter disappearance (DMD) of four particle sizes of dry rolled corn

Particle size (mm)	Average DMD[d]	Hours of incubation	Average DMD[e]
	Percent	Hrs.	Percent
6.0	4.98[a]	2	6.65[a]
3.0	4.38[a]	4	8.98[b]
1.5	9.74[b]	6	9.98[bc]
0.75	18.38[c]	8	11.87[c]

[abc]Means in a column with different superscripts are significantly different ($p<.05$).
[d]Averaged over times (2, 4, 6 and 8 hr.).
[e]Means averaged over all sizes (6.0, 3.0, 1.5, 0.75).

with time, however, was not as great as change due to particle size, suggesting that particle size has a greater effect on DMD than time with unprocessed corn; at least for the short incubation periods used in this experiment.

Experiment 2

Table 2 shows DMD values for SF and DG corn, averaged over time or size. SF corn had higher DMD (size means) within each particle size than DG. These results are in agreement with other studies which have shown steam flaked corn is more completely digested in the rumen than dry, unprocessed corn. Comparing particle sizes within a corn type shows that DMD increased as particle size was reduced from 3.0 mm. (23.81 percent) to 1.5 mm. (28.51 percent), and 0.75 mm. (32.92 percent). Changes in DMD with reduced size of DG corn were similar to those observed in Experiment 1, with an approximate doubling of DMD as size was halved. These results suggest that although particle size affects DMD of SF corn, the magnitude of DMD change with reduced particle size (i.e. a doubling effect) is not as great as with DG. As can be seen by time means, significantly more dry matter disappeared within each time period for SF than for DG.

Experiment 3

More DMD was noted within each particle size for HM than for DG. (Table 3). Furthermore, comparison within corn type indicates that reducing particle size in both HM and DG resulted in increased DMD. In contrast to SF corn (Experiment 2), the magnitude of change in DMD with HM was quite large as size was reduced. This suggests that corn particle size may be an important consideration with regard to ruminal digestion of high moisture corn. The effect of incubation period (time means) was slight for HM and was similar to previous results in regard to DG.

Experiment 4

DMD increased as size decreased from 6.0 mm. (16.12 percent) to 3.0 mm. (19.43 percent) to 1.5 mm. (30.83 percent) to 0.75 mm. (46.32 percent),

Table 2. Nylon bag DMD of steam flaked and dry ground corn

Corn		Particle size DMD means[c]		
		3.0 mm.	1.5 mm.	0.75 mm.
SF		23.8^a	28.5^a	32.9^a
DG		4.7^b	8.4^b	17.7^b
Corn		**Incubation time means[d]**		
	2	4	6	8
SF	21.3^a	24.4^a	29.3^a	38.7^a
DG	7.8^b	8.1^b	10.8^b	14.3^b

[ab]Means in a column with different superscripts are significantly different ($p<.05$)
[c]Means averaged over all times (2, 4, 6, 8 hr.) within a corn type.
[d]Means averaged over all sizes (3.0, 1.5, 0.75 mm) within a corn type.

Table 3. Nylon bag DMD high moisture and dry ground corn

Corn	Particle size DMD means[c]			
		3.0 mm.	1.5 mm.	0.75 mm.
HM		16.8 mm.	23.8[a]	38.9[a]
		7.9[b]	12.4[b]	22.2[b]
Corn	**Incubation time means[d]**			
	2hr	4hr	6hr	8 hr
HM	25.1[a]	25.0[a]	26.4[a]	29.6[a]
DG	10.6[b]	12.6[b]	15.0[b]	19.3[b]

[ab]Means in a column with different superscripts are significantly different ($p<.05$).
[c]Means averaged over all incubation times with a corn type.
[d]Means averaged over all particle sizes within a corn type.

suggesting that longer time for incubation did not overcome the effect of particle size on DMD. Increased length of incubation did, however, result in large increases in DMD as can be seen by time means.

Experiment 5

To determine if relationships between particle size and DMD observed previously with corn occur in other grains, three sizes of sorghum were incubated for two, four, six or eight hours. Little difference was observed in DMD between 3.0 mm. and 1.5 mm. within a time period, but 0.75 mm. sorghum was higher than 3.0 mm. and 1.5 mm. in all cases. Thus, one could safely assume particle size has an important impact on the DMD of sorghum as well as corn.

In conclusion, this study suggests particle size has significant effects on nylon bag dry matter digestion of both corn and sorghum. Moreover, processing grain by steam flaking or high moisture has an additional effect on DMD above that due to particle size alone. Some alteration of whole or near whole kernels appears to be necessary to achieve maximum ruminal digestion of unprocessed corn and may also be necessary with high moisture corn. Whether diets of small particle size would be more completely digested in the

Table 4. Nylon bag DMD of four particle sizes of dry rolled corn with extended incubation times

Size	Particle size means[g]	Time	Incubation time means[h]
mm	Percent	hr	Percent
6.0	16.1[a]		
3.0	19.4[b]	12	22.0[e]
1.5	30.8[c]	24	34.4[f]
.75	46.3[d]		

[abcd]Means in a column with different superscripts are significantly different ($p<.05$).
[ef]Time effect significant ($p<.002$).
[g]Means averaged over all incubation times.
[h]Means averaged over all particle sizes.

Table 5. Nylon bag DMD of three particle sizes of sorghum

Time	Particle size 3.0 mm.	1.5 mm.	0.75 mm.
2	8.4[a]	8.1[a]	22.8[b]
4	15.5[a]	9.7[b]	24.4[c]
6	15.4[a]	12.1	28.8[b]
8	20.9[a]	16.3[b]	36.2[c]

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

rumen than those of layer size is dependent on the other factors. If large particles are held back in the rumen for longer times than small particles, diets of large size may be digested to the same extent as diets of small particle size. More information relative to ruminal outflow rate of grains of different particle sizes is needed to fully understand *in vivo* particle size, digestion relationships.

Influence of Particle Size and Level of Intake on Site and Extent of Digestion in Steers Fed Corn Based Diets

M. L. Galyean, D. G. Wagner, F. N. Owens and K. L. Mizwicki

Story in Brief

Four young Hereford X Brown Swiss steers were utilized to examine the site and extent of dry matter, organic matter and starch digestion in corn based diets. Corn ground through either 3.18, 4.76 and 7.94 mm. screens or left in the whole form was fed in 72 percent corn diets to determine the influence of corn particles size on site of digestion (Trial 1). In Trial 2 a basal corn diet (84 percent corn) was fed at 1.00, 1.33, 1.67 or 2.00 times calculated maintenance dry matter needs in an effort to investigate the influence of level of intake on site of digestion.

Results of Trial 1 showed that total tract dry matter (DMD) and organic matter (OMD) digestion tended to increase as particle size increased. Rumi-

nal DMD, however, was lower for whole corn (44.87 percent) than for 3.18 mm. (62.29 percent), 4.76 mm. (63.62 percent) and 7.94 mm. (60.78 percent). Total tract starch digestion was lower for whole corn than other treatments as was ruminal starch digestion. More starch passed to the intestine with whole than with ground treatments. Data suggest that some alteration of the whole kernel (beyond mastication damage) is needed to obtain maximum ruminal starch digestion.

Increasing level of intake (Trial 2) resulted in decreased total tract DMD, OMD and starch digestion. Ruminal digestion of these nutrients (five) was similar across treatment, but followed the same trend (decreasing with level of intake). Much more dry matter bypassed to the intestine as level of intake increased from 1.00 to 2.00 times maintenance. Level of intake appears to be an important factor relative to starch digestion, and thus efficiency of dietary energy use.

Introduction

Previous work at this laboratory has demonstrated that particle size has an important effect on nylon bag dry matter digestion of corn, whether processed or unprocessed. Whether particle size affects total digestion depends on the time grain stays in the rumen; that is, if large particles are held back for longer periods than small particles, they may be digested to the same extent as small particles. Methods which allow separation of digestion into that occuring ruminally or intestinally may help answer this question. In addition, most digestion studies with cattle are done with animals fed at or near maintenance intake. Increasing level of intake might alter results of these studies.

Therefore, two trials were conducted to determine the influence of particle size (Trial 1), and level of intake (Trial 2) on the site and extent of dry matter (DM), organic matter (OM), and starch digestion in cattle fed high concentrate, corn diets.

Materials and Methods

Trial 1—Four Brown Swiss X Hereford steers (avg. 272 kg.), fitted with permanent rumen cannulae and housed in individual metabolism stalls were used in a 4X4 Latin square design. In this design, four ten-day feeding periods were used, and each steer received a different ration in each period so that by the end of the trial each diet had been fed to all four steers.

Steers were fed one of four diets in eight equal portions daily by means of an automatic feeding system. Treatments were particle sizes of corn in the diet. One lot of corn was either ground through 3.18, 4.76, and 7.94 mm. screens or left in the whole form. These four particle sizes of corn were mixed in 72 percent corn diets (Table 1).

Table 1. Composition of experimental diets

Ingredient	% (Trial 1)	% (Trial 2)
Corn	72.00	84.00
Cottonseed hulls	16.80	4.80
Dehy alfalfa	4.80	4.80
Soybean meal	4.42	4.42
Urea	0.64	0.64
Salt	0.50	0.50
Dicalcium phosphate	0.40	0.40
Calcium carbonate	0.40	0.40
Aurofor-50	0.02	0.02
Vitamin A (30,000 IU/gm)	0.02	0.02

The first six days of each feeding period served as an adjustment to new diets, and a total collection of feces was taken on days seven through ten. Feces was weighed daily, sampled, dried, and ground for chemical analysis. On days nine and ten of each period, rumen samples were obtained via the cannula, dried, and ground for analysis. Diet samples were also obtained during each period.

Diet, fecal, and rumen samples were analyzed for dry matter, ash, lignin, and starch. Ration and fecal samples were analyzed for crude protein. Digestion of nutrients in the rumen was determined by calculating the ratio of lignin in feed to lignin in rumen samples.

Trial 2—Methods used in this trial were the same as those reported in Trial 1. Steers weighed an average of 285 kg. and treatments were multiples of maintenance intake. An 84 percent corn diet (Table 1) was fed at 1.00, 1.33, 1.67 or 2.00 X calculated maintenance dry matter (M) needs (range of intake, 2.6 to 5.3 kg.). Geometric mean diameter of the corn grain which had been ground through a 4.76 mm. screen was 714.49 microns, and dry matter, organic matter, crude protein, starch, and lignin percentages, respectively, of the diet were 89.13, 96.36, 12.67, 67.20, and 3.09.

Statistical analysis were conducted on the data from both trials and significant differences are denoted by superscripts in the following tables.

Results and Discussion

Trial 1—Chemical composition of the four diets was similar as would be expected. Dry matter, organic matter, crude protein, starch, and lignin percentages, respectively, of the diets were as follows: whole (89.53, 96.27, 11.19, 57.80, 5.11); 3.18 mm. (89.56, 96.39, 11.81, 55.76, 4.16); 4.76 mm. (89.53, 96.16, 11.31, 57.99, 4.09), and 7.94 mm. (89.74, 96.08, 11.44, 56.64, 4.61). Geometric mean diameter (microns) of the grains was: whole (5977.87), 3.18 mm. (508.94), 4.76 mm. (587.56), and 7.94 mm. (832.22).

Because of problems associated with taking samples from the rumen rather than abomasum, and variable digestion of ligin; ruminal, and intestinal digestion coefficients are probably not accurate estimates, but should be sufficient indicators of trends. Total tract digestibilities are more valid estimates, however, since they were obtained by total collection methods.

Digestion coefficients as influenced by corn particle size are shown in Table 2. Total tract DMD was similar for all treatments, but tended to increase with increasing particle size. Total tract OMD followed a similar pattern. Ruminal DMD, however, was lower for whole (44.87 percent) than for 3.18 mm. (62.29 percent), 4.76 mm. (63.62 percent), and 7.94 mm. (60.78 percent). Since ruminal DMD was lower for whole, a greater percentage of dry matter passed to the intestines and was digested there, suggesting that intestinal digestive capacity was able to compensate for reduced ruminal digestion of whole corn. This might not be the case, if steers used in this study had been fed larger amounts of dry matter per day (intake in the study was about 3.5 kg. DM/day or 1.25 times maintenance).

Starch digestion coefficients suggest a trend for lower total tract starch digestion as particle size increased, (94.52 percent for ground diets *vs*. 88.18 percent for whole). Ruminal starch digestion was lower for whole (70.83 percent) than for 3.18 mm. (92.02 percent), 4.76 mm. (90.18 percent), and 7.94 mm. (92.96 percent). Due to sampling and marker problems mentioned previously, ruminal digestion coefficients are overestimates and resulted in low and sometimes negative calculated values for intestinal digestion. As can also be seen from Table 2, crude protein digestion was not different across particle size.

Data from Trial 1 suggest that corn particle size has little effect on site and extent of digestion if corn is ground to some degree. It appears, however, that

Table 2. Digestion coefficients of corn based diets as influenced by particle size

Item	3.18 mm.	4.76 mm.	7.94 mm.	Whole
Total DMD %	75.55	76.12	76.52	77.10
Total OMD %	76.07	76.69	77.08	77.43
Ruminal DMD %	62.29[a]	63.62[a]	60.78[a]	44.87[b]
Ruminal OMD %	64.88[a]	65.71[a]	63.89[a]	47.34[b]
DM entering intestinal, dig %	33.33[a]	34.06[a]	39.72[a]	54.50[b]
OM entering int, dig %	28.85[a]	31.26[a]	35.87[a]	51.99[b]
Total starch dig %	94.52	93.65	93.52	88.18
Ruminal Starch dig %	92.02[a]	90.18[a]	92.96[a]	70.83[b]
Starch entering int, dig %	15.93	5.19	-31.11	-2.18
Crude protein dig %	69.23	67.88	67.57	69.56
Total lignin digestion %	27.88[a]	27.99[a]	38.55[b]	53.27[c]

[ab]Means in a row with different superscripts are significantly different ($p<.05$).

Table 3. Digestion coefficients of a corn based diet as influenced by level of intake[c] (percent)

Item	1.00 X M	1.33 X M	1.67 X M	2.00 X M
Total DMD, %	85.70[a]	84.09[a]	78.89[b]	77.64[b]
Total OMD, %	86.36[a]	84.69[a]	79.45[b]	78.22[b]
Ruminal DMD, %	66.22	63.27	59.40	60.14
Ruminal OMD, %	69.92	67.04	63.07	63.12
DM entering int, dig %	52.58	55.98	46.75	41.40
OM entering int, dig %	48.72	51.96	42.29	37.53
Total starch dig %	99.64[a]	98.38[a]	93.80[b]	90.41[b]
Ruminal starch dig %	94.48[a]	92.79[ab]	92.36[ab]	89.46[b]
Starch entering int, dig %	23.00	31.54	-35.09	-25.31
Crude protein dig %	78.86	77.43	74.15	76.79
Total lignin dig %	51.61	52.92	51.54	51.58

[ab]Means in a row with different superscripts are significantly different ($p<.05$).
[c]Least squares means. One steer failed to eat 2.00 m resulting in one missing value in the Latin square.

some alteration of the whole kernel, beyond mastication damage, is necessary to obtain maximum ruminal starch digestion and perhaps greater efficiency of dietary energy use.

Trial 2—Crude protein digestion (Table 3) was similar across treatment, but tended to decrease with increased intake. Problems associated with ruminal sampling methods and marker recovery as noted previously in Trial 1, make estimates of ruminal and intestinal digestion coefficients useful to indicate only relative treatment differences in this trial also.

Total tract DMD was significantly lower for 2.00 times maintenance (2.00 X M), and 1.67 X M than for 1.33 X M, and 1.00 X M, as was total OMD. Part of the decrease in total DMD and OMD may be due to a trend for lower ruminal DMD and OMD coefficients as intake increased. Ruminal DMD declined from 66.22 percent (1.00 X M) to 60.14 percent (2.00 X M) as intake doubled. Intestinal DM and OM digestion coefficients tended to decline as intake increased, suggesting as more feed bypassed fermentation, intestinal digestive capacity may have been too limited.

Steers fed 1.00 X M (99.64 percent), and 1.33 X M (98.38 percent) had higher total starch digestibilities than those fed 1.67 X M (93.80 percent), and 2.00 X M (90.41 percent). Less starch was digested in the rumen as intake increased from 1.00 X M (94.48 percent) to 2.00 X M (89.46 percent). Overestimates of ruminal digestion, as in Trial 1, resulted in low and negative intestinal digestion coefficients in this trial also.

Trial 2 data suggest level of intake has important effects on site and extent of dry matter, organic matter and starch digestion. Researchers should attempt to obtain maximum intake in future digestion studies with cattle fed high concentrate diets to more closely simulate feedlot conditions.

Comparison of Feedlot Performance and Carcass Traits Among Various Three-Breed Cross Calves

C. G. Chenette, R. R. Frahm, A. B. Cobb and J. Eason

Story in Brief

Feedlot performance and carcass traits were compared among 118 steers and heifers of various three-breed crosses. The heifers were placed in feedlot directly after weaning, and the steers were grazed on wheat pasture and placed in feedlot as yearlings.

Shorthorn and Red Poll were used as the sire breeds. On the average, differences in calf performance between these two sire breeds were not large but consistently favored the Shorthorn sires. Calves sired by Shorthorn bulls were in the feedlot six fewer days, gained 0.29 pounds more per day, were 32 pounds heavier at slaughter, and required 0.4 pound less feed per pound of gain than calves sired by Red Poll bulls.

These three-breed cross calves were produced by seven different kinds of two-breed cross cows (Hereford x Angus, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus, and Jersey x Hereford). Calves from the Jersey cross cows required the least amount of days on feed (129 days) and hence had one of the lightest slaughter weights at 818 pounds. Calves from Brown Swiss cross cows averaged 141 days in feedlot with one of the heaviest final weights at 903 pounds. The Brown Swiss and Simmental crosses averaged 0.35 pounds/day more rapid gain than the Jersey crosses but required eight to 12 days longer on feed to grade choice. Calves from Hereford x Angus, Simmental crosses, and Brown Swiss x Hereford cows had similar feed efficiency (averaged 7.52 pounds of feed per pound of gain) and were more efficient than the Brown Swiss x Angus and Jersey crosses by 0.65 pounds of feed per pound of gain on the average. Differences among crossbred cow groups with respect to carcass traits were not large.

Introduction

Beef cattle producers have constantly been searching for ways to increase efficiency of production. Crossbreeding represents a genetic means for markedly improving production efficiency. It has been repeatedly shown that systematic crossbreeding systems can increase percent calf crop weaned and calf weaning weights, such that the pounds of calf weaned per cow in the

In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

breeding herd will be increased 20 to 25 percent. At the present time an extensive research program is underway at the Oklahoma Agricultural Experiment Station to compare the lifetime productivity of various two-breed cross cows mated to a bull of a third breed. It is important to also evaluate feedlot performance and carcass merit of the various three-breed cross calves produced, in order to evaluate various crossbred combinations relative to their total efficiency of producing beef.

Experimental Procedures

Red Poll and Shorthorn bulls were mated to seven different two-breed cross heifers (Hereford x Angus, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus, and Jersey x Hereford) to produce their first calves during the spring of 1975. These two sire breeds were used primarily as an attempt to avoid excessive calving problems with two-year old heifers. Three bulls from each sire breed were used in these matings.

The calves were born in January, February, and March of 1975 at the Lake Carl Blackwell Range Research Area and remained with their dams on native grass until they were weaned September 11, 1975, at an average age of 205 days.

Feedlot performance and carcass merit were evaluated on 118 calves (55 steers and 63 heifers). Following weaning all calves were shipped to the Southwestern Livestock and Forage Research Station at El Reno, OK. The heifers were placed in feedlot immediately, and the steers were grazed on wheat pasture and placed in the feedlot for finishing as yearlings.

Each kind of three-breed cross was randomly assigned a pen in the feeding barn (a total of fourteen pens). Both steers and heifers were self-fed the ration shown in Table 1 during their respective finishing phases. Each animal was removed from the finishing pens for slaughter when it was estimated that a choice carcass grade had been attained.

Table 1. Finishing ration for crossbred calves

Ingredient	Percent in ration
Milo	78
Alfalfa	8
Cottonseed hulls	4
Molasses	5
Supplemental pellets[1]	5
	100

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

Results and Discussion

Comparison of sire breeds

Feedlot performance and carcass traits for each sire breed averaged over both sexes and all seven dam breeds are presented in Table 2. The initial on-test weight for calves of both sire groups was similar. Shorthorn cross calves were in the feedlot six fewer days on the average, gained 0.29 pounds more per day, and were 32 pounds heavier at slaughter than calves sired by Red Poll bulls.

As a result of being 32 pounds heavier at slaughter and having a 1.2 percent higher dressing percent, the Shorthorn sired calves were 29 pounds heavier in carcass weight. Shorthorn sired calves had 0.16 inches less fat thickness; 0.24 percent less kidney, heart, and pelvic fat; and 0.6 square inches larger rib-eye area and thus were 1.2 percent higher in cutability than the Red Poll sired calves. In addition, Shorthorn cross calves required 0.4 fewer pounds of feed per pound of gain.

Differences in performance were not large between these two sire breeds; however, they consistently favored the Shorthorn bulls. Part of this difference may simply reflect differences between the particular bulls used rather than real breed differences.

Table 2. Feedlot and carcass traits of three-breed cross calves sired by Shorthorn and Red Poll bulls

Trait	Breed of sire		Differences
	Shorthorn	Red Poll	(S-RP)
Number of animals	59	59	--
Initial weight, lb.	508	493	15
Final weight, lb.	878	846	32*
Days in feedlot	133	139	-6*
ADG, lbs./day	2.90	2.61	.29*
Slaugher weight, lb.	878	846	32*
Carcass weight, lb.	539	510	29*
Dressing percent	61.4	60.2	1.2*
Single fat thickness, inches	0.87	1.03	-0.16*
KHP, percent	2.69	2.93	-0.24*
Carcass conformation[1]	11.1	10.4	0.7*
Marbling[2]	5.7	5.3	0.4*
Carcass grade[1]	10.6	10.5	0.1
REA, square inches	10.7	10.1	0.6*
Cutability, percent	48.0	46.8	1.2*
Feed efficiency (lb. feed/lb./gain)	7.64	8.03	-0.39

*Differences significant at the .05 probabiliby level. Since all animals of a breed group were in one pen, feed efficiency could not be tested for significance.
[1]Carcass conformation and grade equivalents: 10=low choice, 11=average choice.
[2]Marbling score equivalents: 5=small, 6=traces.

Table 3. Feedlot performance

Trait	Breed of dam[1]						
	HxA, AxH	SxA	SxH	BSxA	BSxH	JxA	JxH
Number of animals	28	15	9	13	13	21	19
Initial weight, lb.	447	514	494	523	506	513	507
Final weight, lb.	815	891	885	900	899	818	828
Days in feedlot	139	135	139	141	141	129	129
ADG lb./day	2.69	2.95	2.94	2.76	2.88	2.50	2.56
Feed efficiency, (lb. feed/lb. gain)	7.66	7.53	7.41	8.12	7.49	8.28	8.11

[1]A=Angus, H=Hereford, S=Simmental, BS=Brown Swiss and J=Jersey.

Comparison of crossbred dam groups

Table 3 presents the feedlot performance of three-breed cross calves produced by each two-breed cross dam group averaged over both sire breeds and sexes. The initial on-test weights varied with the Hereford-Angus crosses at 448 pounds being the lightest by 47 pounds. The Brown Swiss crosses, Simmental crosses, and Jersey crosses all were similar in initial on-test weight (average of 508 pounds). All calves were placed on-test the same day and at similar ages, and thus the variation in initial weight among crossbred groups was primarily due to differences in dam milk production and differences in genetic growth potential of the calves.

Jersey cross calves required the least amount of days on feed (129 days), and hence had one of the lightest slaughter weights at 818 pounds. The Brown Swiss crosses were in the feedlot the longest (141 days) with one of the heaviest final weights at 903 pounds. The Simmental crosses were similar in final weight (889 pounds) to the Brown Swiss crosses but spent four days less time in the feedlot; while the Hereford-Angus crosses were similar to the Brown Swiss crosses for days on feed (139 days) yet had one of the lightest final weights at 816 pounds. The Brown Swiss and Simmental crosses averaged 0.35 pounds per day more rapid gain than the Jersey crosses but required eight to 12 days longer on feed to grade choice.

Pounds of feed required per pound of gain was similar for calves produced by Hereford x Angus, Simmental crosses, and Brown Swiss x Hereford cows (averaged 7.52). This was 0.4 fewer pounds of feed per pound of gain on the average than was required by calves produced by Brown Swiss x Angus and Jersey cross cows.

Carcass traits are presented in Table 4 of calves produced by each crossbred dam group averaged over both sire breeds and sexes. The differences in carcass grade were small as each calf was sent to slaughter when an anticipated choice carcass grade was attained. There were very few major differences between calves of various crossbred dam groups for the carcass

Table 4. Carcass traits

Trait	HxA, AxH	SxA	SxH	BSxA	BSxH	JxA	JxH
	Breed of dam						
Number of animals	28	15	9	13	13	21	19
Slaughter weight, lb.	812	891	884	900	899	819	828
Carcass weight, lb.	496	542	545	551	552	495	491
Dressing percent	60.9	60.9	61.5	61.2	61.4	60.3	59.1
Single fat thickness, in.	1.01	0.94	1.04	0.94	0.94	0.87	0.92
KHP, percent	2.80	2.75	2.90	2.89	2.77	2.77	2.80
Carcass conformation[1]	10.8	10.9	11.5	10.8	11.4	10.0	9.76
Marbling[2]	5.9	5.9	5.0	4.9	5.5	5.8	5.7
Carcass grade[1]	10.8	10.8	10.0	10.1	10.7	10.7	11.0
REA, square inches	9.5	10.8	10.9	10.8	10.8	10.0	9.88
Cutability, percent	46.8	47.6	47.0	47.4	47.5	47.9	47.5

[1]Carcass conformation and grade efficiencies: 10=low choice, 11=average choice.
[2]Marbling score equivalents: 4=slight, 5=small, 6=traces.

traits. The calves were quite similar in fat thickness (averaged 0.95 inches and ranged between 0.87 inches to 1.01 inches), KHP fat (averaged 2.81 percent and ranged between 2.75 and 2.90 percent), marbling (averaged small amount), grade (averaged low choice), and cutability (averaged 47.4 percent and ranged from 46.8 to 47.9 percent). Brown Swiss crosses at 903 pounds and Simmental crosses at 889 pounds were heaviest at slaughter and thus had heavier carcass weights than either the Jersey crosses or Hereford-Angus crosses by at least 47 pounds. The Jersey and Hereford-Angus crosses averaged 816 pounds at slaughter with 493 pound carcasses. The Jersey crosses had a lower dressing percentage (59.7 percent) than all other crosses by at least 1.2 percent, with all other crosses being similar (averaged 61.1 percent). The Jersey crosses lacked carcass conformation by at least nearly one-third of a grade in comparison to other crossbred groups. Brown Swiss crosses and Simmental crosses had larger rib eye areas than Hereford-Angus crossed calves by 1.2 square inches and Jersey crosses by 1.0 square inch.

Overall, differences among calves produced by the seven kinds of crossbred cows used in this study were not very large. This may suggest that a commercial producer may be able to adequately involve several different kinds of crossbred cows in his breeding program and simply mate them all to an unrelated breed of bull. This would permit some flexibility in acquiring crossbred replacement heifers for their herd.

Feedlot Performance and Carcass Merit of Progeny of Hereford, Hereford x Holstein and Holstein Cows

R. D. Wyatt, K. S. Lusby, M. B. Gould, L. E. Walters, J. V. Whiteman and R. Totusek

Story in Brief

The effects of breed of dam on postweaning feedlot performance and carcass merit of 217 steer and heifer calves from four- and five-year-old Hereford, Hereford x Holstein, and Holstein cows was determined. Calves were all sired by Charolais bulls, and were produced in two successive years. Each year 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.

Holstein progeny was heavier at weaning (121 lb.) and at slaughter (229 lb.) than their Hereford contemporaries. Holstein progeny was older at slaughter (64 days), and showed more skeletal height and length both at weaning and at slaughter than Hereford progeny. Crossbred progeny was intermediate with respect to these traits.

As percent Holstein breeding increased, there was a trend toward increased daily and total feed intake, and in feed required per pound of gain.

Holstein progeny produced carcasses which were 81 pounds heavier than crossbred, and 154 pounds heavier than Hereford progeny. Superior muscling of Hereford progeny was indicated by larger rib-eye-area per 100 pounds of carcass weight, and a slight tendency toward higher cutabilities. Conformation scores tended to be lower for Holstein progeny when compared to Hereford or crossbred progeny. Marbling scores and carcass grades of Holstein progeny were as high or higher than those for Hereford and crossbred progeny.

Introduction

Previous research has shown that weaning weights can be greatly improved by increasing the milk production of beef cows. The fastest method of increasing milk production in a beef herd is by adding dairy breeding to the herd. However, heavier weaning weights produced by cows with a percentage of dairy breeding will probably influence both the feedlot performance and carcass merit in the feedlot.

In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

The purpose of this experiment was to compare the feedlot performance and carcass merit of calves with 0, 25 and 50 percent Holstein breeding when fed to approximately the same grade.

Experimental Procedure

Feedlot performance and carcass characteristics of 217 calves with 0, 25 or 50 percent Holstein breeding were determined. Calves were from four- and five-year-old Hereford, Hereford x Holstein (crossbred), and Holstein dams (calving for the third and fourth time) sired by Charolais bulls, and produced in two successive years.

Cows and calves were maintained either on tallgrass native range (154 calves) or confined in drylot (63 calves) from birth to weaning. Treatments consisted of two levels of winter supplement (moderate and high) fed to cows of each breed on range and in drylot. An additional supplement level (very high) was fed to a group of Holstein cows and resulted in calves produced by cows of seven breed-supplement combinations.

Allotment to drylot was made on the basis of calf sex so that a ratio of three males:two females was established within each breed-treatment combination each year. Calves were born in December, January, and February, and weaned at 240 ± 7 days. Drylot calves were creep-fed while range calves received only grazed forage.

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

Skeletal size was estimated from either 20.3 x 25.4 cm. photographs or 5.1 x 5.1 cm. slides taken with each calf behind a grid at weaning, and prior to slaughter. Height was defined as the distance from hip (tuber coxae) to the floor, and length as the horizontal distance from the point of the should (dorsal anterior humerus) to hip. The hip and point of shoulder were marked with contrasting chalk prior to photographing to facilitate more accurate measurements.

Calves from drylot cows were individually-fed *ad libitum* in box stalls from four pm to eight am and placed as a group in an outside loafing area for the remainder of the day. Calves from range cows were group-fed *ad libitum* in a bar with a covered feeding area and an outside loafing area.

Group-fed calves received a 75 percent concentrate ration consisting (percent): ground 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 (percent); whole corn, 87.0, cottonseed hulls, 5.0; and a pelleted supplement containing (percent) 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 estimation of apparent fatness. Final weights and photographs were taken after a 12 hour fast.

Group-fed calves were slaughtered in a commercial packing plant and chilled for 72 hours before quality grade; marbling score; maturity; conformation score; and kidney, heart and pelvic (KHP) fat were estimated by a U.S.D.A. 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 back fat 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. Since previous level of supplement of the dams did not influence feedlot performance or carcass traits of the calves, the results are shown by breed only. As the percentage of Holstein breeding increased, initial weight (weaning weight) increased among both group and individually-fed calves. Crossbred progeny (calves from crossbred dams), and Holstein progeny (calves from Holstein cows) averaged 66 and 121 pounds heavier initial weights than Hereford progeny (calves from Hereford dams). Heavier initial weights were a reflection of the higher preweaning milk intakes, and larger mature size as Holstein breeding increased.

Table 1. Effect of breed of dam on feedlot performance of group-fed calves sired by Charolais bulls, average of two years

Item	Breed of dam		
	Hereford	Hereford x Holstein	Holstein
Initial wt, lb.	568	629	689
Slaughter wt, lb.	10001	1089	1210
Age at slaughter, days	432	449	476
Days fed	192	209	236
Daily gain, lb.	2.31	2.22	2.27
Daily feed intake, lb.	19.6	20.5	24.2
Total feed intake, lb.	3747	4257	5702
Lbs. feed/lb. gain	8.45	9.17	10.66
Skeletal size			
Initial height, in.	39.5	41.3	43.3
Initial length, in.	28.0	28.5	29.3
Slaughter height, in.	46.7	47.3	49.6
Slaughter length, in.	32.6	33.7	36.8

Table 2. Effect of breed of dam on feedlot performance of individually-fed calves sired by Charolais bulls, average of two years

Item	Breed of dam		
	Hereford	Hereford x Holstein	Holstein
Initial wt.	561	629	682
Slaughter wt.	981	1107	1228
Age at slaughter, days	402	460	486
Days fed	162	220	246
Daily gain	2.64	2.20	2.24
Daily feed intake	17.8	18.0	20.0
Total feed intake	2906	3945	4910
Lbs. feed/lb gain	6.88	8.26	9.04
Skeletal size			
Initial height	40.8	42.3	43.6
Initial length	26.6	27.3	28.9
Slaughter height	44.4	46.9	49.2
Slaughter length	32.0	32.8	34.3

Slaughter weight trends were similar to those for initial weight. As percentage of Holstein breeding increased, slaughter weight increased among both group- and individually-fed calves. Crossbred and Holstein progeny was 108 and 229 pounds heavier at slaughter than Herefords. The heavier slaughter weights seen in this experiment reflect increased age at slaughter, and longer feeding period as Holstein breeding increased.

As the percentage of Holstein breeding increased, the number of days on feed required to reach the estimated low choice carcass grade increased. Since all calves were placed on feed at 240 ± 7 days, longer feeding period resulted in comparable increases in age at slaughter.

Among group-fed calves, breed of dam had little affect on average daily gain. However, among individually-fed calves Hereford progeny gained 0.44 and 1.40 pounds daily faster than those of crossbred or Holstein dams. These results differ from some experiments where faster gains were seen for straight-bred Holsteins than for Herefords when fed to an equal weight or time basis. Growth trials based on equal time or weight end-points favor later maturing Holsteins over the smaller, earlier maturing Herefords. In experiments reported in this paper calves were fed from an equal initial age to a similar degree of fatness at slaughter.

Among group-fed calves, there was a trend toward increased feed intake (daily and total), and poorer feed efficiency (more feed/gain) as Holstein breeding increased. Among individually-fed calves, Holstein progeny consumed 2.2 and 2.0 pounds more feed daily than Hereford and crossbred progeny. Daily feed intake was similar for Hereford and crossbred progeny. Total feed consumed during the feeding period increased as Holstein breeding increased. Feed required per pound of gain among individually-fed calves decreased with each percentage increase in Holstein breeding.

Initial skeletal measurements (at weaning) indicated that Holstein progeny were taller and longer than Hereford progeny. Crossbred progeny was intermediate in height and length between Hereford and Holstein progeny.

Carcass traits

Carcass traits of group-fed and individually-fed calves are summarized in Tables 3 and 4, respectively. Carcass weight increased with each percentage increase of Holstein breeding. Crossbred and Holstein progeny produced carcasses 73 and 154 pounds heavier than those of Hereford progeny. These observations are consistent with previous research at Oklahoma State University, and are a reflection of the larger mature size and longer feeding period as Holstein breeding increased. Carcass weight per day of age tended to increase as Holstein breeding increased.

Group-fed Holstein and crossbred progeny produced carcasses with 0.8 and 0.67 in^2 larger REAs than Herefords with a similar trend evident among individually fed calves. The superiority of Hereford progeny for muscling was apparent when REA was expressed per 100 pounds of carcass weight. On this basis, REA/100 pounds of carcass weight decreased with each increment of increased Holstein breeding.

External fatness was one of the criteria used to estimate carcass grade of the live animal, and subsequently determine the time of slaughter. Therefore, some control was exercised over fat thickness in the carcass. Among group-fed calves, fat thickness did not differ due to breed of dam. However, among individually-fed calves, crossbred progeny tended to be fatter than Hereford or Holstein progeny.

Table 3. Effect of breed of dam on carcass traits of group-fed calves sired by Charolais bulls, average of two years

	Breed of dam		
Item	Hereford	Hereford x Holstein	Holstein
Hot carcass wt.	618	678	768
Carcass wt/day of age	1.45	1.52	1.61
Rib eye area	11.8	12.5	12.6
REA/100 lb carcass, $in.^2$	1.92	1.85	1.64
Fat thickness	.70	.70	.68
KHP fat[a]	3.42	3.15	3.27
Cutability, %	48.8	48.7	48.1
Conformation score[b]	11.5	11.0	10.6
Marbling score[c]	12.2	12.5	14.3
Carcass grade[b]	8.9	9.1	9.7

[a]Kidney, heart and pelvic fat.
[b]9 = high good, 10 = low choice, 11 = average choice.
[c]12 = slight +, 13 = small -, 14 = small, 15 = small +

Table 4. Effect of breed of dam on carcass traits of individually-fed calves sired by Charolais bulls, average of two years

	Breed of dam		
Item	Hereford	Hereford x Holstein	Holstein
Hot carcass wt.	603	693	761
Carcass wt/day of age	1.49	1.52	12.4
Rib eye area	12.0	12.7	12.4
REA/100 lb carcass, in^2	2.0	1.84	1.63
Fat thickness	.55	.70	.60
KHP fat[a], %	3.14	3.32	3.64
Cutability, %	49.8	48.5	47.8
Conformation score[b]	10.9	10.4	9.3
Marbling score[c]	14.6	14.5	14.4
Carcass grade[b]	10..1	10.1	10.1

[a]Kidney, heart and pelvic fat.
[b]9= high good, 10 = low choice, 11 = average choice.
[c] = slight +, 13 = small -, 14 = small, 15 = small +

Kidney, heart, and pelvic fat did not show a consistent trend due to breed of dam. Among group-fed calves, Hereford progeny had a lower percentage of KHP fat than crossbred progeny with Holsteins intermediate. Among individually fed calves, Hereford progeny were intermediate. Cutability tended to increase as percentage of Holstein breeding increased.

Conformation score tended to decrease as Holstein breeding increased. Group-fed Hereford progeny had higher conformation scores than Holstein progeny with crossbreds being intermediate. Among inividually fed-calves, Hereford and crossbred progeny had higher conformation scores than Herefords. Among group-fed calves, Holstein progeny was higher in marbling score and carcass grade than Hereford or crossbred progeny. Marbling score and carcass grade was not affected by breed of dam among individually-fed calves.

These results suggest that longer feeding periods and decreased feed efficiency may adverseiy affect the profitability of feeding calves with high percentages of Holstein breeding compared to beef breeds when fed to an equal carcass grade. Calves of 25 or 50 percent Holstein breeding will yield carcasses of comparable quality to beef calves when fed to an equivalent quality grade. However, Holstein crossbred progeny will produce larger carcasses which may be difficult to merchandise.

The Comparison of Three-Breed Cross And Backcross Swine For Litter Productivity And Feedlot Performance

E. R. Wilson, R. K. Johnson, R. Vencl and S. D. Welty

Story in Brief

Crossbred gilts of Duroc, Hampshire and Yorkshire breeding were mated to produce backcross litters (mating crossbred gilts to a boar of one of the two breeds that were the same as the breeding of the gilt) or three-breed cross litters (mating a crossbred gilt to the third breed of boar). A total of 199 backcross and 100 three-breed cross litters were compared for sow productivity from birth to weaning, while 137 backcross and 63 three-breed cross litters were compared for feedlot performance from 40 to 220 pounds. The type of mating did not influence litter size or pig weight at birth. However, survival rate to weaning for three-breed crosses was 2.3 percent greater than for backcrosses, and three-breed cross litters had $0.42 \pm .28$ more pigs per litter at weaning than backcross litters.

Three-breed cross pigs grew significantly faster, 0.05 pound per day, and were five days younger at 220 pounds than the backcross pigs. Three-breed cross pigs also gained more efficiently than backcross pigs from 40 to 220 pounds. Three-breed cross pigs required 2.99 pounds of feed per pound of gain compared to 3.12 pounds of feed per pound of gain for the backcross pigs. There was no difference between the two groups for backfat probe at 220 pounds.

Introduction

Crossbreeding is an effective way to increase the total efficiency of swine production. Crossbred litters produced by crossing two pure breeds have given a 15 percent increase over purebreds in litter weight at weaning. An additional 20 percent has been realized by mating a two-breed cross sow to a

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boar of a third breed. Other advantages of crossbred pigs over purebreds are faster (8 percent) and more efficient (3 percent) growth.

Near maximum productivity can be attained when crossbred sows are producing three-breed cross pigs. This system, however, requires purchasing replacement females or maintaining purebred herds within the system to produce the crossbred females. A system preferred by most commercial producers is rotating purebred boars of two, three or four breeds and saving replacement females. Since in the rotation, the sow will contain some percentage of the same breed as the boar, some loss in heterosis is expected. In addition, the rotation system does not make maximum use of the differences in mothering ability, growth and carcass merit of the breeds involved, as each breed gets used both in the sire and the dam side of the rotation.

To identify mating systems that maximize the productivity of crossbred females, crossbred gilts of Duroc, Hampshire and Yorkshire breeding were mated to purebred Duroc, Hampshire and Yorkshire boars to produce backcross and three-breed cross litters. These results will assist breeders in deciding how best to mate breeds for maximum efficiency in their particular system.

Experimental Procedure

The purebred boars and crossbred gilts used in this study were raised at the Stillwater Swine Farm and transported to the Southwestern Livestock and Forage Research Station, El Reno, prior to the breeding season. The records of approximately 100 gilts for each of three seasons, fall 1975, spring 1976 and fall 1976 are included in the litter productivity data. Only the pigs from the first two seasons have completed the feedlot trial and are included in the feedlot performance data.

The mating scheme used each season is shown in Figure 1. Five to six boars from each breed were each mated to two gilts from each breed group. Gilts were checked daily for estrus and were hand mated on two consecutive days to the same boar. A two-month breeding season began December 1 for the spring farrowing and June 1 for the fall farrowing.

The gilts were farrowed in confinement and the litters were penned separately until weaned at 42 days. Creep was provided at approximately 21 days. Two weeks after weaning the pigs were transported to the confinement finishing barns and allotted to pens by breed group with approximately 16 pigs per pen. After a one-week adjustment the pigs were weighed on test. The pigs were weighed off test at weekly intervals as they reached 220 pounds. All pigs were probed for backfat when they were weighed off test. Total feed consumed per pen was recorded from nine weeks of age to 220 pounds and used to measure feed efficiency.

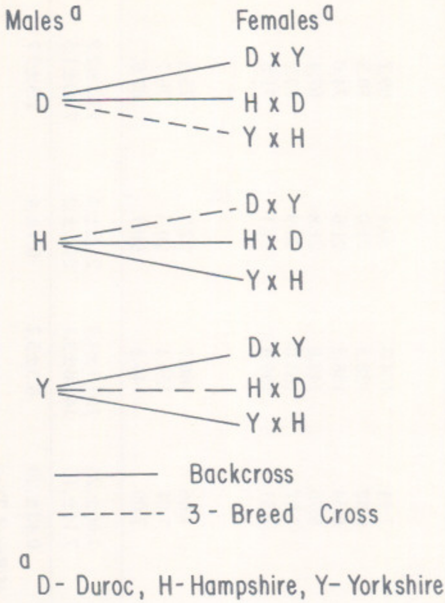

Figure 1. Breeding system.

Results

There were essentially no differences between backcross and three-breed cross litters for litter size, litter weight or average pig weight at birth (Table 1). Previous studies have shown that individual pig heterosis is not responsible for increased litter number at birth; however, maternal heterosis for litter size, which is the increase in number born from a crossbred female, has been significant. Since all of the females in this study were crossbred, there was no difference between backcross and three-breed litters for maternal heterosis. Therefore, litter birth traits would not be expected to differ for three-breed or backcross litters.

Duroc x Yorkshire gilts farrowed 10.44 pigs as compared to 10.06 for Duroc x Hampshire and 10.18 pigs for Hamshire x Yorkshire gilts. When mated to a Yorkshire boar, Duroc x Yorkshire gilts had the largest average litter size at birth 11.03 pigs.

Three-breed cross litters were 0.46 larger and 8.3 pounds heavier at 42 days than were backcross litters. Litter size at 42 days is the average number of pigs raised per gilt raising a litter to 42 days. The average litter size at 42 days was 7.58 for Duroc x Yorkshire females, 7.24 for Hampshire x Yorkshire females and 7.02 for Duroc x Hampshire females. The differences between female breed groups for litter size were very similar at birth and 42 days due to

Table 1. Litter productivity of three-breed and backcross litters at birth and 42 days

	No. of litters[2]	Birth No.	Birth Litter wt., lbs.	Birth Pig wt., lbs.	42 days No.	42 days Litter wt., lbs.	42 days Pig wt., lbs.	Survival percent
Backcross[1]								
D x D-H	35-33	10.49	29.1	2.76	7.44	154.3	20.4	69.2
D x D-Y	34	9.91	28.4	2.91	6.82	138.5	21.0	70.5
H x D-H	28	9.29	27.7	3.09	6.54	138.2	21.6	74.0
H x H-Y	34-33	10.11	27.6	2.77	6.76	143.8	21.8	67.4
Y x D-Y	33	11.03	29.6	2.71	7.97	163.8	20.9	73.2
Y x H-Y	35	10.43	29.0	2.81	7.31	154.4	21.1	71.8
3-Breed Cross								
D x H-Y	33-32	10.00	27.5	2.79	7.66	166.7	22.3	75.5
H x D-Y	33	10.39	29.2	2.85	7.94	159.1	20.5	76.7
Y x D-H	34.33	10.38	30.5	2.98	7.09	145.5	20.7	67.6
3-Breed Cross	100-98	10.26±.26	29.1±.7	2.87±.05	7.56±.23	157.1±4.7	21.2±.4	73.3±2.2
Backcross	199-196	10.21±.18	28.6±.5	2.84±.03	7.14±.16	148.8±3.1	21.1±.2	71.0±1.5
Difference		0.05±.32	0.5±.9	0.03±.06	0.42±.28	8.3±5.7	0.1±.4	2.3±2.7
Average Performance For Gilts of Breed Type								
D x H	97-94	10.06±.26	29.1±.7	2.94±.05	7.02±.23	146.0±4.8	20.9±.4	70.3±2.2
D x Y	100	10.44±.26	29.1±.7	2.82±.05	7.58±.23	153.8±4.6	20.8±.4	73.5±2.2
H x Y	102-100	10.18±.25	28.0±.7	2.79±.05	7.24±.23	155.0±4.6	21.7±.4	71.6±2.2

[1]D-Duroc, H-Hampshire, Y-Yorkshire, (Breed of sire x crossbred female).
[2]Number of litters at birth and 42 days, respectively.

Table 2. Feedlot performance of three-breed and backcross pigs.

	No. of litters	Avg. daily gain, lbs.	Age at 220 lbs.	BF probe 220 lbs., in.	No. of pens	Feed / Gain	Daily feed intake, lbs.
Backcross[1]							
D x D-H	22	1.43	197	1.24	5	3.10	4.43
D x D-Y	25	1.47	193	1.22	7	3.03	4.48
H x D-H	17	1.42	198	1.09	4	3.21	4.49
H x H-Y	24	1.41	198	1.08	5	3.13	4.41
Y x D-Y	26	1.46	194	1.19	7	3.16	4.41
Y x H-Y	23	1.35	202	1.18	5	3.08	3.91
3-Breed Cross[1]							
D x H-Y	20	1.52	187	1.21	9	2.92	4.30
H x D-Y	22	1.46	194	1.08	8	2.97	4.11
Y x D-H	21	1.43	195	1.23	8	3.08	4.29
3-Breed Cross	63	1.47±.02	192±1.9	1.17±.013	25	2.99±.03	4.23±.09
Backcross	137	1.42±.01	197±1.3	1.17±.009	33	3.12±.02	4.36±.08
Difference		0.05±.024*	-5±2.3*	0.00±.015		-0.13±.03**	-0.13±.12

*P<.05
**P<.01
[1]D-Duroc, H-Hampshire, Y-Yorkshire (Breed of Sire x crossbred female)

the similar survival rates for pigs out of each gilt breed type. Survival rate was measured as the percentage of pigs raised per litter that farrowed. Three-breed cross litters had a slightly higher survival rate than backcross litters (73.3 percent compared to 71.0 percent). This slight reduction in survival may be due to the decrease in individual pig heterosis in the backcross pigs since backcross pigs will have one-half the heterosis as the three-breed cross pigs.

Although three-breed cross litters weighed 8.3 pounds more at 42 days than backcross litters, there was essentially no difference in average pig weaning weight between the two groups. Duroc x Yorkshire and Hampshire x Yorkshire females had heavier litters at 42 days than did Duroc x Hampshire females. Hampshire x Yorkshire females had the heaviest average pig weight (21.7 pounds) at 42 days as compared to 20.9 pounds for Duroc x Hampshire and 20.8 pounds for Duroc x Yorkshire.

In the feedlot, three-breed cross pigs grew significantly faster, 0.05 pound/day, and were five days younger at 220 pounds than were backcross pigs (Table 2). These differences are approximately one-half the difference between purebred and two-breed cross pigs for growth rate and days to 220 pounds which have been previously reported. Three-breed cross pigs required significantly less feed per pound gain (0.13 lbs. feed/lb. gain) than the backcross pigs required. This advantage for the three-breed pigs is somewhat greater than expected based on previous results. There was no difference between the two groups for backfact probe at 220 pounds.

Differences in performance of pigs by each breed of sire are similar to what has been found in other studies. Duroc sired pigs grew the fastest and had the lowest feed/gain ratio. Yorkshire and Hampshire sired pigs were very similar for both traits. Hampshire sired pigs, however, had the least backfact probe at 220 pounds, while Yorkshire and Duroc sired pigs were very similar in probe backfat thickness.

The differences between three-breed crossbred litters and backcross litters are very similar to the expected differences based on the purebred and two-breed crossbred performance of these breeds. This suggests that litter productivity performance for backcross litters or other breeding systems can be predicted from purebred performance and heterosis estimates of two-breed crosses.

Swine at Two Degrees of Fatness Fed to 220, 250 and 280 Pounds Live Weight: Feedlot Performance and Carcass Characteristics

J. D. Neely, R. K. Johnson, L. E. Walters and Rex Vencl

Story in Brief

Growth rate, feed efficiency and carcass characteristics of pigs of two degrees of fatness carried to final weights of 220, 250 or 280 pounds were measured on 200 crossbred gilts and barrows of Duroc, Hampshire, and Yorkshire breeding. Pigs were separated into lean and fat groups on the basis of litter average backfat probe at 150 pounds. Within each of the fat and lean groups, an equal number of pigs was taken to each of the designated weights.

At 150 pounds, the fat group had 0.08 inches more backfat than the lean group. At slaughter, the pigs in the fat group had 0.1 inches more backfat, 2.60 percent less lean and 3.10 percent more fat in the carcass than pigs in the lean group. There was virtually no difference between lean and fat groups for carcass length or loin-eye area. Fat and lean groups also had similar feed efficiencies throughout the growth period. Fat pigs did grow somewhat faster than lean pigs early in the growing period, but growth rate of fat pigs declined somewhat beyond 200 pounds while lean pigs maintained a nearly constant growth rate from 160 to 280 pounds.

Growth rates increased steadily as the pigs went from 40 to 160 pounds, but changed little as the pigs went from 160 to 220, 250 or 280 pounds. Feed efficiency, however, declined steadily as pigs increased in weight. However, there was very little difference in feed efficiency from 180 to 220, 250 or 280 pounds. In addition, almost no differences existed in percent lean and fat of pigs slaughtered at each weight; however, backfat, length and loin-eye area increased linearly as slaughter weight increased.

Introduction

Today the majority of slaughter hogs in the United States is marketed at approximately 220 pounds live weight. Carrying hogs to heavier weights would increase the total pounds of product per litter and reduce the number of animals needed to produce the same total pounds of market weight. However, whether or not hogs should be carried to heavy weights will depend on the

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decrease in feed efficiency to heavy weights and on differences in carcass composition of heavy hogs and 220 pound hogs. There has been limited research in the past to evaluate feedlot performance and carcass characteristics of hogs at different degrees of fatness at heavier weights.

In the fall of 1975 this study was initiated to evaluate feedlot performance and carcass characteristics of pigs fed to live weights of 220, 250 and 280 pounds. This report summarizes two seasons where pigs of two degrees of fatness fed to three weights were compared for feedlot performance and carcass characteristics.

Experimental Procedure

The feedlot performance records and carcass data of 200 barrows and gilts, representing 36 litters that were three-quarters of either Duroc, Hampshire or Yorkshire breeding were utilized. Pigs were farrowed in the Southwest Livestock and Forage Research Station swine facilities in the 1975-fall and 1976-spring farrowing seasons.

Litters were produced by backcrossing two-breed cross dams to purebred boars. For example, a Duroc boar was mated to Duroc x Hampshire and Duroc x Yorkshire dams so that pigs were three-fourths Duroc and one-fourth Hampshire or Yorkshire. Litters of three-fourths Hampshire and Yorkshire breeding were produced similarly.

Each season six backcross litters by each breed of sire, containing at least six pigs per litter, were randomly chosen and fed in litter groups of six pigs per pen. Pigs within litters were selected to keep the sex ratio as equal as possible. Litters were fed in solid concrete floor confinement facilities from nine weeks of age to a final weight of 220, 250, or 280 pounds. When each litter averaged 150 pounds, all pigs in the litter were probed for backfat and, within breed of sire, litters were sorted into the three lean and three fat litters on the basis of the litter's average backfat thickness. Within each of the lean and fat groups, the three litters were randomly designated to be slaughtered at 220, 250 or 280 pounds.

Individual pig weights and pen feed consumption were measured every 28 days for the first 112 days of the test. No pigs were removed from test before the end of the fourth 28-day period. Pigs were then removed from test weekly as they reached the designated slaughter weight and were transported to the University Meat Laboratory for carcass evaluation. Total feed consumed from the end of the fourth 28-day period to when the pen was emptied was also recorded.

All pigs were held off feed and water for 36 hours prior to slaughter. Following slaughter of the pigs produced in the first season (1975-fall), the right half of each carcass was separated into separable fat, lean and bone. Carcasses from the animals produced in the second season (1976-spring) were

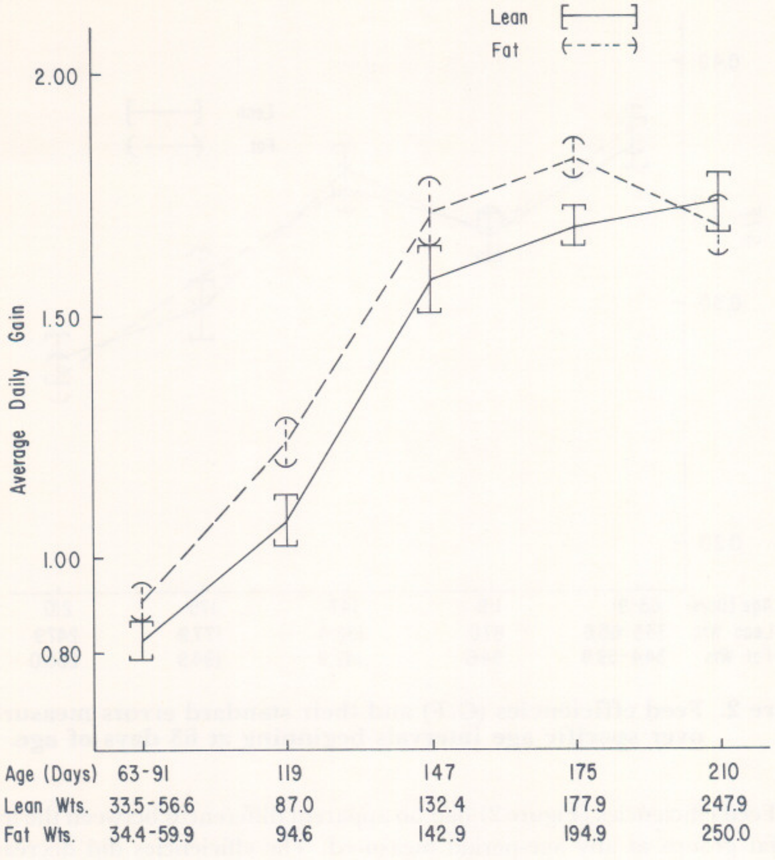

Figure 1. Average daily gain and their standard errors measured over specific age intervals beginning at 63 days of age.

separated into closely trimmed lean cuts (shoulder, loin and ham). In addition, standard carcass measurements were taken.

Results

Average daily gains, when compared on an age to age basis (Figure 1), were somewhat higher at young ages for the fat group than for the lean group. Rates of gain increased steadily for the lean and fat groups from 0.83 and 0.91 to 1.68 and 1.83 pounds per day, respectively, between 91 and 175 days of age. However, when the pigs in the fat group reached 175 days of age their rate of gain decreased while growth rate for the lean group remained virtually constant for the duration of the test.

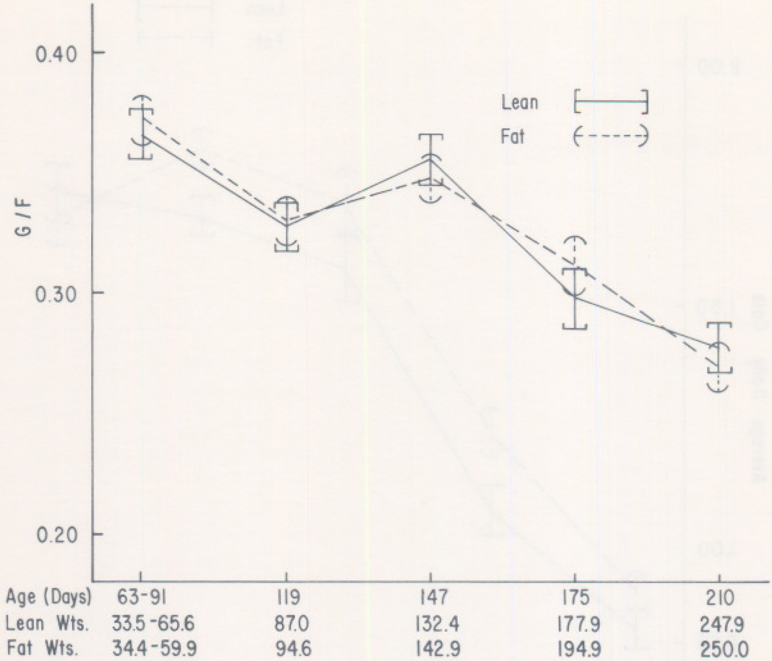

Figure 2. Feed efficiencies (G/F) and their standard errors measured over specific age intervals beginning at 63 days of age.

Feed efficiencies (Figure 2) had no apparent differences between the lean and fat groups at any age-period measured. The efficiencies did decrease, however, from 0.368 to 0.305 pounds of gain per pound of feed (averaged over lean and fat groups) between 91 and 175 days of age, respectively. In the final period it required 3.52 pounds of feed per pound of gain from 187 to 220 pounds live weight, while 3.89 pounds of feed was required to produce a pound of gain from 220 pounds to 250 or 280 pounds.

To better illustrate growth rate to weights of 220, 250 and 280 pounds, average daily gain, on a weight to weight basis, is presented in Figure 3. Although average daily gains were not significantly different for any weight range measured, the pigs in the fat group tended to gain at a faster rate during the earlier stages of growth (40 to 160 pounds) and the lean group tended to have a more rapid gain in the later stages of growth (160 to 280 pounds). The fat group's rate of gain increased from 1.18 to 1.84 pounds per day between 40 to 100, and 100 to 160 pounds live weight, respectively, but steadily decreased to 1.60 pounds per day between 250 and 280 pounds. The rate of gain in the lean group increased from 1.10 to 1.89 pounds per day between the weights of 40 to 100 and 100 to 220 pounds, respectively. After 220 pounds the pigs in the

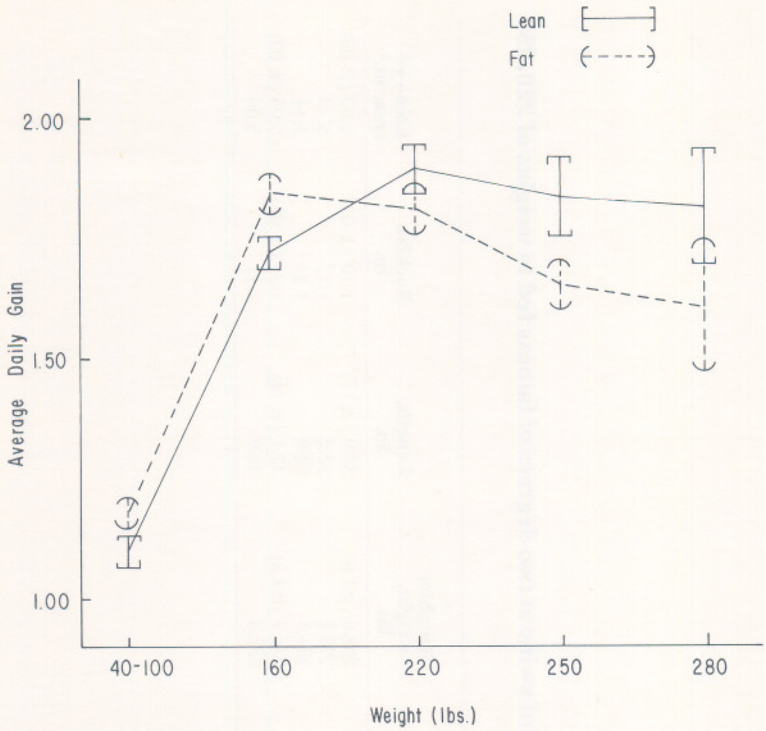

Figure 3. Average daily gains and their standard error measured from weight to weight beginning at 40 pounds.

lean group had a virtually constant rate of gain (1.82 pounds per day) to 280 pounds live weight.

Carcass data, presented in Table 1, show that the fat and lean groups had similar carcass lengths (32.1 and 31.9 in., respectively) and loin-eye areas (5.05 and 5.06 in.^{2}, respectively). However, the fat group did have significantly more carcass backfat (0.10±.02 in.) than the lean group. Carcass lengths (30.9, 32.2, and 32.9 in.), carcass backfat (1.10, 1.17, and 1.21 in.) and loin-eye areas (4.60, 5.13, and 5.44 in.^{2}) increased linearly as the pigs went to 220, 250 and 280 pounds, respectively.

Averaged over slaughter weights, the fat group had 2.60 percent less lean and 3.10 percent more fat than the lean group (Table 2), but essentially the same percent bone and percent closely trimmed cuts. Also, the three slaughter-weight groups (220, 250 and 280 pounds) all had similar percent lean, fat, and bone, but percent closely trimmed lean cuts (58.2, 58.0, and 56.4 percent, respectively) tended to decrease as weight increased.

These data suggest that feed efficiency decreases as weight increases and that fat pigs gain at a faster rate than lean pigs at lighter weights, while lean

Table 1. Off-feed weights and carcass characteristics of swine at two degrees of fatness fed to weights of 220, 250 or 280 pounds

Group	No. pigs	Probe backfat at 150 lbs. in.	Off feed weight, lbs.	Slaughter weight, lbs.	Length, in.	Backfat, in.	Loin-eye area, in.[2]
220 (S.E.)	67	0.893 (±.014)	221.9 (±1.6)	208.6 (±1.6)	30.9 (±.17)	1.10 (±.03)	4.60 (±.09)
250	62	0.890	250.5	238.1	32.2	1.17	5.13
280	71	0.880	278.3	264.3	32.9	1.21	5.44
Fat (S.E.)	102	0.929 (±.011)	250.5 (±1.3)	236.7 (±1.3)	32.1 (±.14)	1.21 (±.02)	5.05 (±.07)
Lean	98	0.846	250.0	237.3	31.9	1.11	5.06

Table 2. Percent lean, fat, and bone and percent closely trimmed lean cuts of swine at two degrees of fatness fed to weights of 220, 250 or 280 pounds

Group	No. litters	Percent lean[a]	Percent fat[a]	Percent bone[a]	Percent closely trimmed lean cuts[b]
220 (S.E.)	6	55.6 (±.92)	31.0 (±1.3)	13.5 (±.40)	58.2 (±.53)
250	6	56.3	29.9	13.7	58.0
280	6	55.8	31.3	13.0	56.4
Fat (S.E.)	9	54.6 (±.75)	32.3 (±1.1)	13.2 (±.33)	57.6 (±.43)
Lean	9	57.2	29.2	13.6	57.5

[a]Percent lean, fat and bone or carcass weight were obtained in the 1975-fall season.
[b]Percent closely trimmed lean cuts of carcass weight were obtained in the 1976-spring season.

pigs have more rapid gains at heavier weights. They also indicate little difference in percent lean, fat and bone as weight increases from 220 to 250 and 280 pounds live weight. Percent closely trimmed lean cuts declined somewhat, however, as pigs reached 280 pounds live weight.

Response of Growing Boars to Lysine Supplemented Corn-Soybean Meal Diets

R. W. Tyler, W. G. Luce, R. K. Johnson and C. V. Maxwell

Story in Brief

A trial was conducted involving 108 growing boars to measure the effect of lysine supplementation on rate of gain, feed conversion, daily feed intake, backfat thickness, and loin eye area. The boars were fed either an 18 percent crude protein ration, a 16 percent crude protein + 0.16 percent added lysine, or a 14 percent crude protein + 0.32 percent added lysine ration from approximately 48 to 120 pounds. The protein level was then reduced 2 percent for each treatment from approximately 120 to 220 pounds body weight. The added lysine resulted in equivalent lysine levels for all treatments during

Periods 1 (48 to 120 pounds), and 2 (120 to 220 pounds) as compared to the standard 18 to 16 percent crude protein rations for the same weight periods.

The results indicate that when lysine was added to the 16 percent ration from 48 to 120 pounds (Phase 1), and to the 14 percent ration from 120 to 220 pounds (Phase 2) growth performance for the boars was equal to the standard 18 to 16 percent crude protein rations.

However, when the crude protein content was reduced 4 percent (18 to 14 percent plus lysine) there was a significant reduction in average daily gains during Period 1 with an increase in feed required per pound of gain. There was also a significant decrease in feed intake and loin eye areas for boars receiving this treatment.

Introduction

Previous work at Oklahoma State University indicated that a 16 percent crude protein ration from 55 to 120 pounds (Phase 1), and a 14 percent crude protein ration from 120 to 220 pounds (Phase 2) was inadequate for growing boars. However, boars fed either a 18 or 20 percent crude protein diet during Phase 1, and a 16 or 18 percent ration during Phase 2 had significant improvements in rate of gain, feed conversion, backfat thickness, and loin eye areas.

This study was initiated to determine if growth performance could be maintained at the level of the control rations (18 to 16 percent crude protein) by keeping the lysine content equal to the control, when the crude protein was reduced.

Experimental Procedure

One hundred and eight purebred Duroc, Hampshire, and Yorkshire boars were used in this study. The boars averaging 47.9 pounds were randomly allotted within breed and litter to three experimental treatments. Each treatment consisted of four replicas containing nine boars each. The boars were housed and group fed in an open-front concrete finishing floor equipped with self feeders and automatic waters.

Materials and Methods

Phase 1

Phase 1 included the time period from the time the boars started test at 47.9 pounds body weight until they had reached an average body weight of 123.6 pounds. The boars on Treatments 1, 2, and 3 were fed an 18 percent C.P., 16 percent C.P. + 0.16 percent additional lysine, and a 14 percent C.P. + 0.32 percent additional lysine ration, respectively. Composition of the experimental rations is shown in Table 1. At the end of Phase 1, average daily gain, feed per pound gain, and average daily feed intake were determined.

Table 1. Composition of experimental rations

Ingredients (percent)	Ration designation (percent)					
	18% C.P.	16% C.P.	16% C.P.	14% C.P.	14% C.P.	12% C.P.
Yellow Corn	64.0	69.5	69.2	74.7	74.5	80.3
Soybean Meal (44%)	27.75	22.1	21.9	16.3	16.0	10.25
Wet Molasses	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
Dicalcium Carbonate	1.5	1.65	1.65	1.75	1.75	1.8
Calcium Carbonate	0.7	0.7	0.7	0.7	0.7	0.6
Vitamin=trace mineral mix[1]	0.5	0.5	0.5	0.5	0.5	0.5
Aureomycin 50	0.5	0.5	0.5	0.5	0.5	0.5
Lysine mix			0.5	0.5	1.0	1.0
Total	100.00	100.00	100.00	100.00	100.00	100.00
% Crude Protein, calculated	17.99	15.99	16.02	14.03	14.02	12.00
% Calcium, calculated	0.69	0.71	0.70	0.71	0.71	0.71
% Phosphorus, calculated	0.61	0.61	0.61	0.61	0.61	0.59
% Lysine, calculated	0.92	0.76	0.92	0.76	0.91	0.76

[1]Supplied 3,000,000 I.U. vitamin A, 300,000 I.U. vitamin D, 4 gm. riboflavin, 20 gm. panthothenic 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.

Phase 2

The boars were started on Phase 2 immediately upon completion of Phase 1. The boars on Treatments 1, 2, and 3 were fed a 16 percent C.P., 14 percent C.P. + 0.16 percent added lysine, and a 12 percent C.P. + 0.32 percent added lysine ration, respectively. The composition of the experimental rations is shown in Table 1. The boars were individually removed from the test on Phase 2 when they reached 220 pounds. Average daily gain, feed per pound gain, and average daily feed intake were determined. In addition, ultrasonic estimates of backfat thickness, and loin eye were obtained by the use of the Ithaco Scanogram Model 721 instrument.

The scanogram readings for estimated backfat thickness were taken at the midline at three locations (the first rib, last rib, and last lumbar vertebra). Loin eye area estimates were made at the tenth rib. All scanogram estimates were adjusted to a 220 pound basis for each boar using the National Association of Swine Records Standards.

Results and Discussion

Phase 1

The results are shown in Table 2. Boars on Treatment 3 had significantly lower average daily gains of 1.33 pounds as compared to gains of 1.61 and 1.56 pounds for boars on Treatments 1 and 2, respectively. Gains for boars receiving Treatment 2 tended to be lower than those on Treatment 1, but the difference was not significant. No large differences were noted in average daily feed intake but boars on Treatment 2 consumed slightly more feed per day.

Table 2. Summary of results for Phase I, Phase II, and Total Period

	Treatments (percent)		
	1 (18-16 %)	2 (16-14 % + lys)[1,2]	3 (14-12% + lys)[1,3]
Pens per treatment, no.	4	4	4
Boars per pen, no.	9	9	9
PHASE I			
Avg. initial wt., lb	48.86	47.86	47.11
Avg. final wt., lb	122.75	123.45	127.60
Avg. daily gain, lb[4]	1.61[4]	1.56[4]	1.33[4]
Feed per lb gain, lb	2.48	2.64	2.83
Avg. daily feed intake, lb	4.00	4.11	3.74
PHASE II			
Avg. initial wt., lb	122.75	123.45	127.60
Avg. final wt., lb	220.25	218.94	200.42
Avg. daily gain, lb	2.08	2.17	2.00
Feed per lb gain, lb	3.06	3.35	3.26
Avg. daily feed intake	6.35	7.25	6.52
TOTAL PERIOD			
Avg. daily gain, lb[4]	1.85[4]	1.84[4]	1.57[4]
Feed per lb gain, lb	2.81	2.92	3.00
Avg. daily feed intake, lb	5.21	5.47	4.69
Adj. backfat thickness, in.	1.02	1.01	1.04
Adj. loin-eye area, sq. in.[4]	5.32[4]	5.38[4]	4.98[4]

[1]Phase I treatments were 18, 16 and 14 crude protein rations for Treatments 1, 2 and 3, respectively. Phase II treatments were 16, 14 and 12 percent crude protein rations for Treatments 1, 2 and 3, respectively.
[2]Both the 16 and 14 percent crude protein rations received 0.16 percent added lysine.
[3]Both the 14 and 12 percent crude protein rations received 0.32 percent added Lysine.
[4]Means with different superscripts are significantly different ($P<.05$)

Results from Phase 1 indicate that a 14 percent crude protein ration based primarily on yellow corn and soybean meal, with additional lysine added, is inadequate for growing boars from approximately 48 to 120 pounds if optimum performance is to be obtained.

Phase 2

Results are shown on Table 2. Although not significant, boars on Treatment 2 (14 percent C.P. + lysine) had slightly higher average daily gains (2.17 pounds) and feed intake per day (7.25 pounds per day) as compared to Treatments 1 and 3. Boars on Treatment 1 (16 percent crude protein) tended to require less feed per pound of gain.

Results from Phase 2 indicate that growing boars from approximately 120 to 220 pounds, when fed a 14 percent + lysine ration or a 12 percent plus lysine ration have similar growth performance to boars on a standard 16 percent crude protein corn-soybean meal ration.

Total Period

Performance data was computed for the total feeding period. Boars on Treatment 3 had significantly lower average daily gains of 1.57 pounds as compared to gains of 1.85 and 1.84 pounds for boars on Treatments 1 and 2, respectively. Feed required per pound of gain tended to increase as crude protein decreased and added lysine increased.

There were no significant differences in backfat thickness for boars receiving the three treatments. Boars on Treatment 1 and 2 had significantly larger loin eye areas of 5.32 and 5.38 square inches as compared to 4.98 square inches for boars on Treatment 3.

These results indicate that a 16 percent crude protein, plus added lysine, ration from approximately 48 to 120 pounds and a 14 percent, plus added lysine, ration from approximately 120 to 220 pounds will support growth equal to a standard 18 to 16 percent crude protein corn-soybean meal based ration.

Based on the reduced average daily gains, reduced feed efficiency, and smaller loin eye areas as compared to the standard ration, the 14 to 12 percent crude protein ration plus lysine was found to be inadequate for growing boars.

Sheep

Summer Lambing Performance of Crossbred Ewes of Finnsheep, Dorset and Rambouillet Breeding When Mated to Purebred or Crossbred Rams

D.L. Thomas, J.V. Whiteman, J.E. Fields and D.J. Stritzke

Story in Brief

Reproductive performance and body weights of four and five-year old crossbred ewes representing five combinations of Finnsheep (F), Dorset (D) and Rambouillet (R) breeding were evaluated when lambing in the summer (June-July, 1976). The five breed combinations represented were ½D, ½R; ¼D, ¾R; ¼F, ½D, ¼R; ¼F, ¼D, ½R and ¼F, ¾R. Breeding effectiveness of purebred and crossbred rams of Hampshire and Suffolk breeding was also compared when mated to these ewes.

Body weights taken before both breeding and lambing indicated that substitution of either Dorset or Finnsheep breeding for Rambouillet breeding resulted in decreased body weight but that less of a decrease resulted from the Finnsheep substitution than from the Dorset substitution.

Results of the summer lambing were quite favorable with the entire flock averaging 1.5 lambs born per ewe exposed. Fertility did not differ greatly among the five crossbred ewe groups with at least 93 percent of the ewes in each crossbred group lambing. The ¼-Finnsheep ewes had a higher lambing rate than did ewes of only Dorset and Rambouillet breeding (1.64 vs. 1.47). This resulted in ¼-Finnsheep ewes giving birth to 22 more lambs per 100 ewes exposed than crossbred ewes of only Dorset and Rambouillet breeding.

With January-February mating, reproductive performance of ewes when mated to either crossbred or purebred rams 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 two years of May-June mating where these same ewes when mated to crossbred rams

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gave birth to an average of 19 more lambs per 100 ewes exposed than those ewes mated to purebred rams.

Introduction

An increase in reproductive rate of the commercial ewe flock offers the greatest single opportunity for increasing efficiency of lamb meat production. Two ways that reproductive rate can be increased are by: (1) infusion of germ plasm of more prolific breeds into our commercial flocks, and (2) adoption of some type of accelerated lambing program to shorten the interval between lambings.

Past research by the Oklahoma Agricultural Experiment Station has shown that crossbred ewes of Dorset x Rambouillet breeding are more productive under Oklahoma farm flock conditions than traditionally used Rambouillet ewes. The Finnish Landrace (Finnsheep) breed from Finland, which is now available to American sheepmen, is noted for its superior lambing rate and offers a possible source of genetic material with which to further improve productivity of commercial ewe flocks of the Southwest.

An accelerated program of lambing every eight months seems feasible when a 5-month gestation period, and a 1.5-month breeding season are considered. Research at this station has shown that ewes of Dorset x Rambouillet breeding produce desirable lamb crops when lambing in either the winter or fall of the year. An accelerated lambing program involving an eight month lambing interval, and incorporating a winter and fall lambing, however, must also include an early summer lambing.

The purpose of this paper is to compare reproductive performance of four and five-year old crossbred ewes of Dorset and Rambouillet breeding with similar ewes containing ¼-Finnsheep breeding when lambing in the summer of 1976. Some data is also included on breeding effectiveness of purebred and crossbred rams when mated to these same ewes.

Materials and Methods

In March and April of 1971 and 1972, approximately 250 crossbred ewes of five combinations of Finnsheep (F), Dorset (D) and Rambouillet (R) breeding were produced at the Southwestern Livestock and Forage Research Station (Ft. Reno), El Reno, Oklahoma. The five breed combinations represented were ½D, ½R; ¼D, ¾R; ¼F, ½D, ¼R; ¼F, ¼D, ½R and ¼F, ¾R. The ¼F, ¾R ewes were produced in 1972 only. Reproductive performance of these ewes when lambing in the winter of 1972, 1973 and 1974 and the fall of 1974 and 1975 has been reported previously in the *Animal Sciences and Industry Research Reports of 1974, 1975 and 1976*.

After lambing in October and November of 1975, ewes nursed their lambs for 70 days or until January 13, 1976. Condition scores could 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.

On January 15, 1976, ewes were divided into single sire breeding groups of 36 to 37 ewes each. 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 of approximately 24 months of age was placed with each breeding group for the duration of the 50 day breeding season.

Prior to commencement of lambing on June 2, 1976, body weights and condition scores were again obtained on each ewe. Lambing started on June 10, 1976, and continued through July. Ewes were lambed under close supervision in a shed or adjacent pasture. Ewes and lambs grazed alfalfa and sudan during the majority of the summer months. Toward the end of summer, dry weather forced the feeding of supplemental baled alfalfa hay. Lambs had access to creep feed during the entire preweaning period. At approximately 70 days of age, lambs were weaned from their dams and switched from creep feed to a feedlot ration.

Results and Discussion

Weights and Scores

Presented in Table 1 are mean weights and condition scores of the five crossbred ewe groups before breeding and lambing. As would be expected, the five crossbred ewe groups ranked the same for weight at both weighings. The ½D, ½R ewes were the lightest, and the ¼F, ¾R ewes were the heaviest followed closely by the ¼D, ¾R ewes. Among the two ewe groups containing only Dorset and Rambouillet breeding and among the three ewe groups containing ¼-Finnsheep breeding, body weights increased as the proportion of Rambouillet breeding increased. One would expect this since Rambouillets reach heavier mature weights than either Dorsets or Finnsheep. It is also of interest to note that when comparing two crossbred ewe groups with the same proportion of Rambouillet breeding, ewes with the greatest proportion of

Table 1. Weights and scores of the five crossbred ewe groups before breeding and lambing

Breeding	Before breeding			Before lambing		
Group	No.	Weight (lbs.)	Score	No.	Weight (lbs.)	Score
½D, ½R	52	132	4.6	50	158	5.3
¼D, ¾R	56	149	4.6	56	175	5.3
¼F, ½D, ¼R	43	140	4.8	41	172	5.5
¼F, ¼D, ½R	51	147	5.3	48	174	5.4
¼F, ¾R	34	151	5.0	33	180	5.8

Finnsheep breeding were the heaviest (¼F, ¾R - 151 pounds vs. ¼D, ¾R - 149 pounds, and ¼F, ¼D, ½R - 147 pounds vs. ½D, ½R - 132 pounds for breeding weights; and ¼F, ¾R - 180 pounds vs. ¼D, ¾R - 175 pounds, and ¼F, ¼D, ½R - 174 pounds vs. ½D, ½R - 158 pounds for lambing weights). These weights would indicate that subsitution of either Dorset or Finnsheep breeding for Rambouillet breeding will result in decreased body weights, but less of a decrease will result from the Finnsheep substitution than from the Dorset substitution.

Crossbred ewe groups did not differ greatly in condition score with all groups scoring very close to a five both times. A five score indicates that the ewes were in average condition.

Ewe Reproductive Performance

The flock average of 1.5 lambs born per ewe exposed to the ram (Table 2) was quite good; especially when it is taken into consideration that this was the first experience with summer lambing at this station and that a majority of these ewes had given birth to lambs approximately eight months previously. In addition to the very acceptable level of reproductive performance, ewes seemed to milk extremely well, and lambs seemed to adjust quickly to the hot temperatures of summer.

Fertility did not differ greatly among the five crossbred ewe groups with at least 93 percent of the ewes in each crossbred group lambing. The ¼-Finnsheep ewes had a higher lambing rate than did ewes containing only Dorset and Rambouillet breeding (1.64 vs. 1.47). The ¼F, ¼D, ½R ewes had the highest average lambing rate (1.75) and the ¼D, ¾R ewes had the lowest (1.42).

Average number of lambs born per ewe exposed is a function of both fertility and lambing rate and is an overall measure of reproductive performance. Since fertility was similar among crossbred ewe groups, ranking of ewe groups for number of lambs born per ewe exposed was similar to that observed for lambing rate. The ¼-Finnsheep ewes gave birth to more lambs per ewe exposed (1.60) than did Dorset-Rambouillet ewes (1.38). The ¼F, ¼D, ½R and ¼F, ½D, ¼R ewes produced the highest average number of lambs born

Table 2. Lambing performance of the five crossbred ewe groups when lambing in the summer of 1976

Breeding group	No. exposed	Ewes lambing		Lambs born		
		No.	%	No.	/Ewe lambing	/Ewe exposed
½D, ½R	49	46	94	70	1.52	1.43
¼D, ¾R	56	52	93	74	1.42	1.32
¼F, ½D, ¼R	40	40	100	65	1.62	1.62
¼F, ¼D, ½R	47	44	94	77	1.75	1.64
¼F, ¾R	33	33	100	51	1.55	1.55
Total	225	215	96	337	1.57	1.50

per ewe exposed (1.64 and 1.62, respectively), and the ¼D, ¾R ewes produced the fewest (1.32).

These preliminary results would indicate that a very acceptable level of reproductive performance may be obtained from the ewe flock with June-July lambing and that ¼-Finnsheep ewes of the breeding used in this study give superior performance over crossbred ewes of Dorset and Rambouillet breeding only. In two years, these same ewes will again be mated to lamb in June and July. If the results of that lambing are as positive as the results of the present study, this station will be in position to recommend to Oklahoma sheepmen an accelerated lambing program (eight month lambing interval) utilizing summer lambing.

Purebred vs. Crossbred Rams

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 (Hampshire x Suffolk or Suffolk x Hampshire) gave birth to an average of 19 more lambs per 100 ewes exposed than ewes mated to purebred rams (Hampshire or Suffolk). The rams tested were approximately 16 months of age at the beginning of the 1974 and 1975 mating seasons.

Five of the eight rams used to produce the lambs born in the fall of 1975 (two purebreds and three crossbreds) and three of their contemporaries (two purebreds and one crossbred) who were retained as reserves but never used in 1975, were used to produce the lambs born in the summer of 1976. Table 3 presents lambing performance of the ewes when mated to either purebred or crossbred rams. Reproductive performance of the two groups was virtually the same whether measured by fertility, lambs born per ewe lambing or lambs born per ewe exposed. These results are certainly in disagreement with the fall lambing results. Some possible explanations for this discrepancy are:

1. When used in January, 1976, these rams were eight months older than when used for the first time in May, 1975 (24 vs. 16 months of age).

Table 3. Lambing performance of the crossbred ewes when mated to purebred and crossbred Hampshire and Suffolk rams during January and February, 1976

	Type of ram	
Item	Purebred	Crossbred
Rams, no.	4	4
Ewes exposed, no.	112	113
Ewes lambing, no.	108	107
Ewes lambing, %	96	95
Lambs born, no.	170	167
Lambs/ewe lambing	1.57	1.56
Lambs/ewe exposed	1.52	1.48

Crossbred rams may reach sexual maturity earlier than purebred rams. Differences in their breeding effectiveness would thus be greater at younger than older ages.

2. Season of mating may have been a major factor. May and June is a season of low sexual activity in the ewe, and conception rates are generally lower to matings during this period than to matings at other times during the year. If crossbred rams are more aggressive in the breeding pastures than purebred rams, crossbred rams may stimulate some ewes to a higher level of sexual activity which will allow them to conceive. This would account for the crossbred ram advantage with May-June mating.

   The high fertility rates of all ewes when mated in January and February suggests that a very high proportion of the ewes were sexually active during this period. This high level of sexual activity in the ewes would not allow the increased aggressiveness of crossbred rams to show itself in the form of greater conception rates.

Future Plans

The ewes will remain on the accelerated lambing program (eight month lambing interval) and evaluation of purebred and crossbred rams will continue.

Feed Efficiency and Carcass Characteristics of Ram and Ewe Lambs Slaughtered at Two Live Weights

R.L. Adams, L.E. Walters, J.V. Whiteman and J.E. Fields

Story in Brief

Forty ram and 40 ewe lambs were used to study the feed efficiency and carcass characteristics of 100 pound and 125 pound slaughter lambs. The animals were obtained from an eight month lambing interval project in progress at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma. Lambs were progeny of crossbred dams of various levels of Rambouillet, Dorset and Finnsheep breeding mated to Hampshire, Suffolk or Hampshire X Suffolk rams.

Feed efficiency data were calculated for the ram and ewe lambs for two different weight gain intervals; 70 to 100 pounds and 100 to 125 pounds live weight. Carcass measurements were taken and carcass composition data obtained at two slaughter weights (100 and 125 pounds) for the lambs.

The average pounds of feed required per pound of gain for rams was lower than for ewe lambs within their respective weight gain intervals. Ram and ewe lambs fed from 70 to 100 pounds required about two pounds less feed per pound of gain than ram and ewe lambs fed from 100 to 125 pounds. Ram lambs gained about 0.2 of a pound per day more than ewes in both weight gain intervals. Ram and ewe lambs fed from 70 to 100 pounds gained about 0.1 of a pound per day faster than ram and ewe lambs fed from 100 to 125 pounds.

From slaughter and carcass data it was observed that ram lambs were three to five percent lower in dressing percentage and about one-third of a grade lower in quality grade, but trimmer in all fat measurements than ewe lambs. Light weight slaughter rams were about two-thirds of a grade lower in quality grade and about three percent lower in dressing percentage than heavy ram lambs. However, light ewe lambs were over a full grade lower in quality grade, but only about 1.4 percent lower in dressing percentage than were heavy ewe lambs. It was observed from carcass composition data that rams yield about four percent more of their carcass weights in closely trimmed major wholesale cuts than ewe lambs. The data also indicate that heavier ram lambs yield two percent less in percent trimmed wholesale cuts than lighter ram lambs; whereas, heavier ewe lambs yield three percent less in percent major wholesale cuts of carcass weight than lighter ewe lambs. *However, when*

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closely trimmed major wholesale cuts were expressed as a percent of live weight, there was little or no difference observed for this trait between ram and ewe lambs (30.0 percent for rams and 30.0 percent for ewes) *or between weight groups within sex*.

Introduction

Lamb, as a meat source, is the most sought after product there is today. This fact is reflected in the price of market lambs sold through lamb markets and in the retail price for lamb in food stores. If the theory behind the law of supply and demand and how this relationship affects price holds true, then along with the high demand for lamb, there must be a *low supply* to cause this high price for lamb. This is in fact the case.

There are many reasons why lamb is in short supply in the retail counter. Factors such as seasonality of the product, distance to slaughter lamb markets and a high number of predatory animals are all detrimental to the supply of lamb. An improvement in any one of these factors could be considered as a possibility for increasing the production of lamb. However, an improvement in any one of these areas would require a long period of time to increase lamb meat supply. There is one alternative to these possibilities that would be much quicker and easier and that is simply to increase the slaughter weight of lambs above the traditional 100 pounds.

Even though increasing slaughter weight provides a quick way for increasing the supply of lamb, there are many problems generated when lambs are fed to heavier weights. Among the most influential problems is the fact that as slaughter weight is increased, the amount of fat deposited and the amount of feed needed to obtain the extra pounds of lamb are also increased.

Whether or not heavier lambs will increase the supply of lamb efficiently will depend on the amount of feed required per extra pound of edible portion and if the increase in fat content in the heavier lamb results in a less desirable cut to the consumer.

The objectives of this study were: (1) to determine the amount of extra feed required per pound of extra live weight gain for ram and ewe lambs fed from 70 to 100 pounds as compared to ram and ewe lambs fed from 100 to 125 pounds, and (2) to determine how much of an effect slaughter weight has on the yield of percent closely trimmed major wholesale cuts of ram and ewe lambs.

Materials and Methods

Crossbred ram and ewe lambs, produced from the matings of Suffolk, Hampshire or Suffolk X Hampshire sires with dams of various levels of Rambouillet, Dorset and Finnsheep breeding were selected from an eight month lambing interval project in progress at the Southwestern Livestock and

Forage Research Station at El Reno, Oklahoma. Dams of these breed groups have been previously shown to not have an appreciable effect on differences in carcass composition of their lambs.

Twenty ram and 20 ewe lambs were selected from a 1975 late fall crop of lambs and an additional 20 ram and 20 ewe lambs were selected from the late-spring, early-summer lambing season of 1976. In each season, there were two pens of 10 rams per pen, and two pens of 10 ewes per pen selected (one ewe lamb from the fall crop of lambs prolapsed and was eliminated from the study).

Each pen of lambs was selected from the experimental flock when 10 rams or 10 ewes were found such that the average weight of the pen was approximately 70 pounds and each lamb in the pen weighed as close to 70 pounds as possible. As each group of 10 lambs was selected, that group was placed in drylot and fed a ration formulation of approximately 45 percent alfalfa, 50 percent milo and 5 percent molasses.

During the early part of the feeding period, individual weights were obtained on a weekly basis. When the average weight of the pen neared 100 pounds, individual weights were obtained twice weekly in order to slaughter a group of five lambs at an average weight as close to 100 pounds as possible. When the average weight of the pen of lambs reached 100 pounds, five of the lambs that would represent the average weight of the pen (100 pounds) were selected for shipment to the OSU Meat Laboratory for slaughter. The remaining five lambs were sheared, then fed and weighed in the same manner as above from an initial weight of 100 pounds to a slaughter weight of 125 pounds minus their wool weights.

A total of four pens of rams and four pens of ewes were fed over two seasons. Feed efficiency values were calculated for each pen rather than for individual lambs; therefore, there were eight observations from which feed efficiency values were computed.

After slaughter, the carcasses were chilled for 24 hours at 34°F. Carcasses were then wrapped with two layers of beef shrouds to decrease dehydration of the lamb carcasses until carcasses were cut.

U.S.D.A. quality grades were determined prior to cutting the carcass. Other carcass data obtained included dressing percent, rib eye area, U.S.D.A. yield grade factors (12th rib fat thickness, percent kidney and pelvic fat and leg conformation score) from which actual U.S.D.A. yield grades were calculated.

The right side of each carcass was broken into the major wholesale cuts to be used to obtain carcass composition data. Each major wholesale cut was trimmed to a retail trim (approximately 0.2 in.) and weighed. After the retail trim the wholesale cut was closely trimmed and re-weighed. The leg and shoulder were then physically lean, fat and bone separated. Yield of trimmed and boned leg and shoulder, closely trimmed rack and loin, and closely trimmed major cuts were calculated on both a carcass and live weight basis.

Results and Discussion

Feed Efficiency

Charcteristic of greatest interest for determining the production efficiency of light and heavy ram and ewe lambs was the amount of feed required per unit of live weight gain. However, since feed per unit of gain is a function of daily feed intake and average daily gain, these two values are also presented. Averages for daily feed intake, average daily gain, and pounds of feed per pound of gain are presented in Table 1 for ram and ewe lambs fed for two different weight gain intervals.

Daily feed intake was 0.4 pounds greater for the rams than for the ewes between 70 and 100 pounds. However, after reaching 100 pounds, the rams increased their daily intake by almost one pound; whereas, the ewes increased their daily feed consumption by only one-third of a pound. Average daily gain was about 0.2 pounds greater for rams than for ewes. Average daily gain decreased by 0.1 pound in rams after they reached 100 pounds; whereas, average daily gain decreased 0.15 pounds. Feed efficiency was much more favorable for the ram lambs than for the ewe lambs within each weight interval.

The data in Table 1 suggest that ram and ewe lambs of this type can be fed to heavier weights without requiring excessive amounts of feed per pound of gain beyond the traditional slaughter weight of 100 pounds. However, the ewe lambs are approaching the point of non-desirability when they are fed to 125 pounds.

Carcass Characteristics

Average for carcass measurements and evaluations taken prior to cutting are presented in Table 2. Data in this table are in close agreement with similar studies on the effects of sex and weight on the characteristics of slaughter lambs. Ram lambs were about two-thirds of a grade lower in quality grade and 1.5 percent lower in dressing percent, but trimmer in all fat measurements and about one full grade lower in yield grade than ewe lambs. (The reader is reminded that the most desirable yield grade is a #1 and the most undesirable yield grade is a #5.) Lighter ram lambs were trimmer in all fat measurements,

Table 1. Averages of feedlot performance of ram and ewe lambs fed for two different weight gain intervals

Item	Ram lambs		Ewe lambs	
	wt. gain interval(lbs)		wt. gain interval(lbs)	
	70 to 100	100 to 125	70 to 100	100 to 125
Daily feed intake (lbs.)	4.35	5.31	3.93	4.27
Avg. daily gain (lbs.)	0.81	0.71	0.61	0.46
Lbs. feed/lb. gain	5.27	7.27	6.48	8.81

Table 2. Averages for fat measurements, yield grade, quality grade, rib eye area and dressing percent for ram and ewe lambs

Item	100	125	100	125
12th rib fat th. (in.)	0.17	0.25	0.32	0.46
% K & P fat	2.92	3.83	4.44	5.44
U.S.D.A. yield grade	2.98	3.68	4.29	5.45
U.S.D.A. quality grade[1]	11.45	12.00	12.15	13.57
Rib eye area (sq. in.)	2.12	2.48	2.15	2.44
Dressing percentage	48.39	52.49	53.99	55.37

[1]14=Ave. Prime; 13=Low Prime; 12=High Choice; 11=Ave. Choice

and two-thirds of a grade lower in yield and quality grade, and four percent lower in dressing percent than heavier ram lambs. Lighter ewe lambs were lower by one percent and one-half quality grade, one and one-third yield grade, and 1.4 percent lower in dressing percent than heavier ewe lambs, but were trimmer in all fat measurements. Rib eye areas were the same for both ram and ewe lambs (2.3 sq. in.) but differed between weight groups within sex. Heavier ram lambs had 0.36 sq. in. more rib eye area than lighter ram lambs; whereas, heavier ewe lambs had 0.29 sq. in. more rib eye area than lighter ewe lambs.

Tables 3 and 4 present the yields of trimmed and boned leg and shoulder, trimmed rack and loin, and percent trimmed major cuts on a carcass and live weight basis. When expressed as a percentage of carcass weight (Table 3), percent trimmed and boned shoulder and leg decreased for both ram and ewe lambs from a 100 pound slaughter weight to a 125 pound slaughter weight. Lighter ram lambs were higher in percent trimmed rack (0.2 percent) and loin (0.72 percent) than heavier rams; whereas, lighter ewe lambs were lower in

Table 3. Averages for percent trimmed major cuts of carcass weight of ram and ewe lambs slaughtered at two live weights

	Ram lambs		Ewe lambs	
	approx. live wt.(lbs)		approx. live wt.(lbs)	
Carcass cut (percent)	100	125	100	125
Trimmed and boned shoulder[1]	15.29	14.88	13.61	12.91
Trimmed rack[2]	8.09	7.88	7.59	7.86
Trimmed loin[2]	13.83	13.11	13.31	12.75
Trimmed and boned leg[1]	18.71	17.54	17.36	16.04
Trimmed major cuts[2]	67.41	65.74	63.65	60.68

[1]Completely lean, fat and bone separated.
[2]Closely trimmed and bone in.

Table 4. **Average for percent trimmed major cuts of live weight for ram and ewe lambs slaughtered at two live weights**

Carcass cut (percent)	Ram lambs approx. live wt.(lbs) 100	Ram lambs approx. live wt.(lbs) 125	Ewe lambs approx. live wt.(lbs) 100	Ewe lambs approx. live wt.(lbs) 125
Trimmed and boned shoulder[1]	6.75	6.85	6.48	6.46
Trimmed rack[2]	3.57	.366	3.62	3.94
Trimmed loin[2]	6.09	6.09	6.34	6.37
Trimmed and boned leg[1]	8.26	8.08	8.26	8.03
Trimmed major cuts[2]	29.75	30.30	30.30	30.40

[1]Completely lean, fat and bone separated.
[2]Closely trimmed and bone in.

trimmed rack (0.3 percent), but higher in percent trimmed loin (0.56 percent) than heavier ewe lambs. Ram lambs yielded 4.2 percent more of their carcass weight in trimmed major cuts than ewe lambs. Lighter ram lambs were 1.7 percent higher in trimmed major cuts than heavier rams; whereas, lighter ewes were 3 percent higher in percent trimmed major cuts than heavier ewes.

Table 4 represents the same carcass traits as Table 3, but they are expressed as a percent of live weight rather than carcass weight. These data indicate that when percentages of carcass cuts were calculated on a live weight basis, little or no differences were observed for these carcass traits between ram and ewe lambs or between slaughter weight groups within or between sexes. The data in this table suggest that ram and ewe lambs can be slaughtered at heavier weights without decreasing the percent closely trimmed major wholesale cuts of *live weight*. This fact should be of economical importance to the producer in that it could influence his decision of whether to feed his lambs to heavier market weights.

Some Relationships Between Measures of Growth and Carcass Composition in Lambs

M. Makarechian[1], A.W. Munson, L.E. Walters and J.V. Whiteman

Story in Brief

Growth and carcass data from four groups of lambs, totalling 244 head born and raised between 1963 and 1966 were used to study the relationships between some measures of growth and carcass composition. All the lambs were from grade Dorset x Rambouillet or grade Rambouillet ewes and were sired by blackface (Hampshire and Suffolk) or whiteface (Dorset) rams and were slaughtered upon reaching 100 pounds.

Lambs sired by blackface rams gained faster after weaning and produced leaner carcasses with more bone than lambs sired by Dorset rams. The carcass composition of single lambs was similar to that of twins except that the percent of bone was slightly higher in single lamb carcasses than in twins. Ram lambs grew faster, were leaner, had more bone and a lower dressing percentage compared with either wether or ewe lambs.

All relationships between measures of growth and carcass composition were weak when considered on a within breed and sex basis. On the average, the heavier lambs at birth produced leaner carcasses with less fat and more bone. Weaning weight was positively associated with the percent of bone and dressing percent of the carcass. There was essentially no relation between post-weaning average daily gain and carcass composition. Generally, the faster gaining lambs after weaning had a lower dressing percentage.

Introduction

There is a growing demand for leaner lamb carcasses by consumers. Many people believe that faster gaining lambs are leaner, and therefore more acceptable. These observers see lambs of different breeds, sexes and types of rearing, and these effects may cause different growth rates and different levels of fat and lean in their carcasses.

Information on the relationships between growth rate and carcass composition in lambs is quite limited.

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In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

The purpose of this study was to determine the relationships of some measures of growth and certain lamb carcass characteristics among lambs slaughtered at about 100 pounds.

Materials and Methods

The records from 244 lambs involving four groups were used in this study. All the lambs were from grade Dorset x Rambouillet or grade Rambouillet ewes of the experimental flock at the Southwest Livestock and Forage Research Station. The lambs were sired by Suffolk or Hampshire (blackface) and Dorset (whiteface) rams. In the 1963 and 1964 data equal numbers of single and twin reared wether lambs were obtained and studied. In the 1965 and 1966 data only twin lambs were utilized but there were equal numbers of ram, wether and ewe lambs each year.

All lambs were born between Oct. 10 and Nov. 25 each year. Ten days to two weeks after birth, they were placed on wheat pasture with their dams with access to a creep ration containing 32 percent ground alfalfa hay, 63 percent ground grain sorghum and 5 percent molasses. The lambs were weaned at about 70 days of age when they weighed a minimum of 46 pounds.

Biweekly weights were taken on the lambs until they approached 95 pounds after which they were weighed weekly. As they reached a full weight of 100 pounds or more they were taken off feed, sheared and transported to Stillwater. The lambs were slaughtered the following morning after being off-feed and water for approximately 18 hours.

All the lambs were slaughtered according to the accepted procedures. The subcutaneous fat was removed from the shoulder, rack, loin and leg and the weight of the fat from each cut was recorded as fat trim. The four major wholesale cuts were boned completely. The neck, foreshank, breast and flank were also boned. The boneless portions were mixed and sampled for chemical analysis. The kidney and pelvic fat were also considered as part of the fat trim.

Fat content of the carcass was the fat trim plus the ether extract of the lean. Bone content was determined by separation techniques and the lean portion was calculated by difference. This method gives a very accurate measure of fat, lean and bone.

In the 1963 and 1964 data, there were equal numbers of single and twin lambs from equal numbers of blackfaced (considered growthier) and whitefaced (considered earlier maturing) sires. This permitted the evaluation of the relationships of genetic differences in growth pattern to the measures of carcass composition. The 1965 and 1966 data involved equal numbers of ram, wether and ewe lambs from the two kinds of sires (not in equal numbers) permitting a study of the relationship of those variables to the measures of growth and carcass composition.

After these relationships were evaluated, the data were adjusted to remove the effects of single *vs* twins, breeds of sire and sex. The relationships (correlations) of the measures of growth to the measures of carcass composition were then evaluated, giving an estimate of what these relationships would

Results and Discussion

The 1963 and 1964 data were used to evaluate effects of breed or sire and single vs twin rearing on measures of growth and carcass composition (Table 1). Breed of sire had little relationship to birth or weaning weights but had considerable effect on postweaning average daily gain in favor of blackfaced sires. This was expected as Dorsets tend to mature at lighter weights as compared with Suffolks and Hampshires. Breed of sire had considerable influence on carcass composition. Carcasses from the faster-gaining lambs sired by blackfaced rams were generally leaner and had a higher percentage of bone than the lambs sired by Dorset rams.

Single lambs were about 1.7 pounds heavier than twin lambs at birth and about 11 pounds heavier at weaning but this did not have an appreciable effect on carcass composition, except that single lamb carcasses had 0.6 percent more bone. Percent wholesale cuts were similar for breed or sire groups and for single and twin lamb carcasses.

The 1965 and 1966 data were used to evaluate the effects of breed of sire and sex on measures of growth and carcass composition (Table 2). For this set of data, the effect of breed of sire on growth measurements was somewhat greater, compared with the results of the 1963 and 1964 experiment. In both groups the lambs by blackfaced sires were generally heavier at birth and weaning and the Suffolk lambs gained considerably faster after weaning. All differences in measures of carcass composition could have been due to chance.

Table 1. Averages of some growth and carcass measurements as affected by breed of sire and rearing type+

	Breed of sire			Rearing type	
	Dorset	Hampshire	Suffolk	Single	Twins
Birth weight, lb.	9.2	9.2	9.6	10.2[1]	8.5[2]
Weaning weight, lb.	53.1	52.4	54.8	59.0[1]	47.9[2]
Post weaning avg. daily gain, lb.	0.54[1]	0.60[2]	0.62[2]	0.60	0.57
Dressing percent	50.5[1]	49.9[2]	49.0[3]	49.6	50.0
Percent wholesale cuts	37.9	37.7	37.5	37.8	37.6
Percent lean	54.0[1]	54.3[1]	57.0[2]	55.2	55.0
Percent fat	30.1[1]	29.5[1]	25.4[2]	28.0	28.7
Percent bone	15.8[1]	16.3[2]	17.7[3]	16.9[1]	16.3[2]

+1963 and 1964 data.
[1,2,3]Averages in the same row, for each factor, with different superscripts are significantly different at 0.05 probability level or less. (Significantly different means that the differences are probably real — not due to chance.)

Table 2. Averages of some growth and carcass measurements as affected by breed of sire, and sex+

	Breed of sire			Sex		
	Dorset	Hampshire	Suffolk	Ram	Wether	Ewe
Birth weight, lb.	8.0^{1}	9.1^{2}	8.6^{3}	9.2^{1}	8.5^{2}	8.1^{3}
Weaning weight, lb.	48.3^{1}	55.5^{2}	55.6^{2}	55.8^{1}	52.1^{2}	51.5^{2}
Post weaning avg. daily gain, lb.	0.60^{1}	0.62^{1}	0.70^{2}	0.73^{1}	0.61^{2}	0.58^{2}
Dressing percent	48.6	49.1	48.5	47.2^{1}	49.5^{2}	49.5^{2}
Percent wholesale cuts	35.9	35.6	35.9	35.6	35.9	35.9
Percent lean	51.1	51.3	52.5	54.9^{1}	50.4^{2}	49.6^{2}
Percent fat	33.3	32.5	30.9	27.4^{1}	33.8^{2}	35.6^{2}
Percent bone	15.6	16.2	16.6	17.8^{1}	15.8^{2}	14.8^{3}

+1965 and 1966 data.

[1,2,3]Averages in the same row, for each factor, with different superscripts are significatntly different at 0.05 probability level or less.

Sex had considerable influence on measures of growth and carcass composition. Male lambs were heavier than ewe lambs at birth. Ram lambs were heavier than either wether or ewe lambs at weaning and had a much faster rate of gain than the other two sex groups after weaning. Ram lambs had a lower dressing percentage and their carcasses were leaner and had more bone as compared to the wether and ewe lamb carcasses. Thus, the faster gain after weaning of ram lambs results in leaner carcasses. These results are generally in agreement with the results reported by other investigators.

After adjusting the data to remove the effects of type of birth and rearing (single vs twins), breed of sire, sex and year of production, the relationships between growth measurements and carcass composition were estimated (Table 3).

Birth weight was related to the percent of lean, percent of fat and percent of bone in the carcass, indicating that generally, lambs that were heavier at birth produced leaner carcasses with more bone and less fat than lambs that were lighter at birth. Birth weight showed a strong relationship with weaning weight, indicating that generally heavier lambs at birth tended to grow faster during the nursing period. There was a very weak relationship between birth weight and postweaning average daily gain.

Weaning weight appeared to have little, if any, relationship with the percent of wholesale cuts, percent of lean and percent of fat in the carcass. However, there was a weak positive association with the percent of bone and dressing percentage.

Postweaning average daily gain can be considered as the best indicator of the animal's genetic potential for growth compared with other growth measurements. Postweaning average daily gain had little, if any, relationship with

Table 3. Correlation coefficients between growth and carcass measurements in lambs of the same breed, sex, and rearing type slaughtered at about 100 pounds

	Weaning weight	Post weaning avg. daily gain	Percent wholesale cuts	Percent lean	Percent fat	Percent bone	Dressing percent
Birth weight, lb.	0.52*	0.13*	0.10	0.30*	−0.37*	0.34*	−0.06
Weaning weight, lb.	—	0.21*	0.04	0.04	−0.10	0.19*	0.26
Post weaning avg. daily gain, lb.	—	—	−0.04	0.10	−0.12	0.10	−0.21*
Percent wholesale cuts	—	—	—	0.39*	−0.28*	−0.13*	0.30
Percent lean	—	—	—	—	−0.94*	0.28*	−0.26*
Percent fat	—	—	—	—	—	0.59*	0.33
Percent bone	—	—	—	—	—	—	−0.33*

*Significant at 0.05 probability level or less. (Correlations are probably not due to chance.)

the measures of carcass composition. There was weak negative correlation with dressing percentage, indicating that generally the faster-growing lambs (after weaning) had a somewhat lower dressing percentage.

These results suggest several things: (1) The big difference in rate of gain of single and twin lambs is not associated with any differences of any great consequence in carcass composition; (2) When later maturing, larger rams sire the lambs, the rate of gain after weaning is increased and the lamb carcasses may be leaner as a result; (3) If male lambs are not castrated they will gain faster after weaning and the resultant carcass will be leaner but the dressing percentage of the lambs will be less and (4) If lambs are sired by rams of the same breed, are of the same sex and are either twins or singles, birth weight is the measure of growth most closely related to percent fat, lean or bone, and that relationship is not strong. In other words, in a group of lambs like these slaughtered at about 100 pounds, there is little or no relationship between rate of gain after birth and carcass leanness.

Dairy Nutrition and Management

Effects of Dietary Phosphorus Levels on Reproductive Efficiency in Dairy Heifers

D. Hecht, M.E. Wells, L.J. Bush and G.D. Adams

Story in Brief

Seventy-six heifers, 38 Holstein, 30 Ayrshire, 6 Guernsey, and two Jersey were used to study the effects of dietary phosphorus level on reproductive capacity. Length and regularity of estrous cycles, number of services required for conception, and percent pregnant were the factors considered. Marker bulls were used to aid in visual detection of estrus. All heifers were bred by artificial insemination. No differences were found between heifers fed minimum daily requirements for phosphorus, and those heifers fed supplemental phosphorus as far as estrus exhibition, services per conception, and pregnancies were concerned. Younger heifers required more services per conception and exhibited more erratic estrus cycles than did older heifers.

Introduction

There have been conflicting reports concerning the effect of phosphorus on reproductive efficiency. Phosphorus levels in the diet ranging from 0.16 to 0.4 percent have been suggested as the cause of problems varying from anestrous cows to increased number of services per conception. However, regular cycling and fertility has been found in cows who have shown other phosphorus deficiency symptoms.

Recommended phosphorus levels for growing heifers are 0.21 - 0.23 percent in the diet. Levels below 0.14 percent are generally considered to be low and conducive to reproductive problems.

The objective of this study was to investigate the relationship between dietary phosphorus levels and reproductive problems in dairy cattle. Specifically, the effects of a low level (0.13 - 0.22 percent) were compared to the effects of supplementation to 0.40 percent phosphorus in the ration.

Experimental Procedure

Seventy-six dairy heifers were divided into two age groups with Group I averaging 10.2 months and Group II, 19.2 months at the start of the experiment. The trial period lasted from June 30, 1976, to December 16, 1976. Each group was then subdivided into a treated or control group. Group I controls were fed free choice alfalfa hay, corn, and pasture resulting in 0.25 - 0.27 percent P in the diet. Group II controls were fed prairie hay *ad libitum*, corn with urea, and pasture resulting in 0.10 - 0.13 percent P in the diet. Treated heifers in both groups were supplemented with monoammonium phosphate to achieve 0.4 percent phosphorus in the diet. Calcium and energy levels were kept constant to meet requirements.

Blood samples were taken every two weeks to determine phosphorus and calcium levels. Weights were measured once a month to monitor growth rate. The heifers were checked for estrus twice daily with the help of deviated bulls wearing chin-ball markers. The breeding season started on October 7 and pregnancy checks were made by a veterinarian 45 - 55 days after the last insemination.

Results and Discussion

Blood phosphorus levels in Group I averaged 7.18 mg percent in the treated group, and 7.01 percent in the control group for a difference of 0.2 mg percent. In Group II the average was 7.61 mg percent for the treated and 6.28 mg percent for the control group, making a difference of 1.3 mg percent. As expected, there was a larger difference among the older heifers than among the younger heifers since the intake differences were larger for the older heifers. Calcium levels were similar for all groups, averaging 9.5 mg percent.

Table 1 summarizes reproductive data for the study. There was no real effect of phosphorus level on the percentage of heifers in each group exhibiting heat in the first 21 days of the breeding season. The percentage ranged from 91 percent to 96 percent, indicating that cycling was not affected. These percentages also indicate that heat detection efforts were quite adequate. All heifers had been bred at least once by day 40 of the breeding season.

A comparison of the percent of the animals conceiving to first service raises some questions. In the older groups, there was no difference, with 65.0 percent of the treated heifers and 66.6 percent of the control heifers conceiving to first service. However, the younger group averaged significantly lower with the supplemental heifers having no apparent advantage over the control heifers. Through the third service, control and treated heifers were similar in conception patterns. The decreased conception percentage to first service in the younger heifers can likely be attributed to their age. They averaged 9 months younger and were just starting their cycles. They also exhibited more erratic cycles (Table 1) with the common problem being short cycles. This

Table 1. Comparison of effects of phosphorus level on dairy heifers

Item measured	Group I (young) Treated		Group I (young) Control		Group II (old) Treated		Group II (old) Control	
Blood phosphorus (mg %)		7.18		7.01		7.61		6.28
No & % in heat 1st 21 days	15/16	93.8	15/16	93.8	20/22	90.9	21/22	25.5
Conc. to 1st Service (%)		46.6		33.3		65.0		66.6
No & percent settled in:								
1st 21 days	7/16	43.8	5/16	31.3	13/22	59.1	14/22	63.6
2nd 21 days	3/16	18.8	3/16	18.8	5/22	22.7	3/22	13.6
3rd 21 days	1/16	6.3	4/16	25.0	1/22	4.5	0	0.0
4th 21 days	3/16	18.8	3/16	12.6	1/22	4.5	1/22	4.5
Total settled (no & %)	14/16	87.5	14/16	87.5	20/22	90.9	18/22	81.8
Avg. services/conc.		2.20		2.45		1.57		1.68
Total irregular cycles (No & %)	16/71	22.5	15/72	20.8	4/84	4.8	9/10	10.0
Total heifers with irregular cycles (No & %)	6/16	37.5	10/16	62.5	3/22	13.6	5/22	22.7

causes difficulty in knowing when to inseminate the animal, and this likely contributed to the lowered conception efficiency reflected in conception to first service as well as average number of services per conception. Table 1 also presents the breeding efficiency by 21-day segments of the breeding season. Older heifers tended to conceive earlier in the breeding season than did younger heifers. However, there was very little difference in the percentages of heifers settled after 84 days of the breeding season.

It has been widely suggested that marginal phosphorus levels cause irregular cycling. Table 1 summarizes the degree of irregular cycling by age and phosphorus level. The greater incidence of irregular cycles was observed in the younger group with about 20 percent of the cycles for the entire study in both treated and controls being an irregular length. The older group had fewer irregular cycles, about five percent and 10 percent, respectively, for treated and control animals. The number of heifers showing irregular heats showed similar patterns with a very strong implication that younger heifers will show a greater incidence of irregular heat periods. The percentages and numbers would suggest that a greater percentage of the heifers on the lower phosphorus level (both young and old groups) exhibited irregular cycles. However, it is doubtful that this is fact.

In the younger animals, there was no difference in blood phosphorus levels in treated and control animals. In the older group, the treated heifers had somewhat higher phosphorus levels than did control heifers. The differences between groups in the number of heifers showing irregular heats was small and could not be uniquely attributed to phosphorus level. It should be pointed out that there were irregular cycles in both age groups and phosphorus levels. Irregularities will be greater in young heifers in the first few cycles following puberty. However, the majority of the heifers quickly settle into a routine cycling pattern. Some small percentage of a heifer population will be difficult or repeat breeders, as is typical with cow populations.

It can be concluded that feeding phosphorus to dairy heifers at the lower end of recommended levels will have little effect on reproductive performance. Supplying additional phosphorus had no discernible effect on reproductive performance. It would be unusual that phosphorus deficiencies could exist in routine heifer raising programs.

Acid Preservation of Alfalfa Hay for Dairy Cows

B.W. Tabor, L.J. Bush and G.D. Adams

Story in Brief

Since high quality forage is essential in a dairy ration, it is improtant to study new methods of preserving hay. In this trial, the effect of a commercial organic acid preservative on nutirent content and feeding value of alfalfa hay was evaluated.

Alfalfa hay from a common field was baled at about 20 percent moisture for a control, and at about 28 percent moisture with addition of 0.1 percent organic acid based hay preservative. In a feeding trial with lactating cows, the control hay supported higher milk production than the hay to which the preservative had been added. Milk fat and non-fat solids content was similar for both groups. Digestibility of dry matter, organic matter and crude protein was slightly higher in rations containing the control hay.

The commercial hay preservative used for this trial was not entirely effective in preventing molding in hay baled at high moisture content. It apparently was not effective in maintaining quality equal to that of hay baled at lower moisture content without a preservative.

Introduction

Alfalfa hay plays a major role in many dairy feeding programs in Oklahoma. Therefore, harvesting of hay with sufficiently high quality to sustain a high level of milk production is important.

A relatively new approach to hay harvesting involves adding a small amount of organic acid to the hay at the time of baling. This permits baling at higher moisture content than would otherwise be recommended and in some instances would reduce nutrient loss due to shattering of leaves in handling. Information is very limited regarding the effect of adding organic acids on the available nutrient content of stored hay, and on its comparative feeding value for lactating cows.

Research workers have found hay quality inversely related to moisture content at baling and to temperature attained during storage. Increase in microbial activity and heating in storage result in increased losses of dry matter, sugars, fats and hemicellulose. High temperature during hay curing also favors a chemical reaction in which sugars and amino acids react to form indigestible compounds. The principal dark-colored nitrogenous compound resulting from this reaction accumulates in the lignin fraction of the cell wall material.

The addition of 2.1 percent acetic:propionic (57:40) acids or 1.1 percent ammonium isobutyrate to a grass-clover mixture containing 35 to 50 percent moisture was found to be reasonably effective in preventing heating and molding in loose stacks. Propionic acid at 1.5 percent was not effective in inhibiting mold under the same conditions. Other workers have observed a higher percent of total nitrogen in the relatively indigestible fraction (ADF-N) in alfalfa hay baled at 25 to 37 percent moisture with the addition of 0.05 percent propionic acid based mold inhibitor than in hay baled at 16 to 19 percent moisture.

Addition of either anhydrous ammonia or propionic acid at a rate of one percent to alfalfa hay baled at 32 percent moisture has been found effective in preventing heating in storage and development of mold. Smaller amounts of propionic acid were not as beneficial in preventing heating of the hay or a decrease in *in vitro* dry matter digestibility. One researcher found the quality and digestibility of alfalfa hay baled at about 29 or 26 percent moisture, with the addition of 0.1 percent commercial mold inhibitor containing 20 percent propionic acid, equal to that of hay baled at 11 or 16 percent moisture.

No reliable data have been reported on the merits of adding organic acid preservatives to hay at baling for feeding to dairy cows.

The purpose of this trial was to evaluate the effect of adding an organic acid product to hay at baling on its nutrient content and feeding value for lactating cows.

Materials and Methods

Hay from a common field was baled under two different conditions as follows: a) control, baled at an average moisture content of about 20 percent, and b) acid treated hay, baled at about 28 percent moisture with additon of 0.1 percent commercial acid product. This product, containing 20 percent propionic acid, was applied with a CO_2 pressure spray unit as the hay moved into the "throat" of the baler.

Twenty lactating cows (14 Holsteins and six Ayrshires) were used in a switchback feeding trial with two treatments. Comparison periods were six weeks in duration, with data from the last five weeks used for analysis, and the first week of each period allowed for change-over from one hay to another. Cows started the first comparison period seven to ten weeks after calving.

The experimental rations consisted of a concentrate mixture and alfalfa hay (50:50 ratio) fed in sufficient quantity to meet NRC requirements based on size, age, milk production, and fat percentage. Allowances were reduced by five percent at the start of the second and third periods to minimize weight changes.

Milk production was recorded twice daily with samples from four consecutive milkings each week composited for analysis of total solids and fat percentage. Body weights were recorded on three consecutive days at the beginning of the trial and during the last week of each comparison period. Digestibility of ration components was determined during the fifth week of each period by using chromic oxide as an indicator.

Results and Discussion

The commercial acid product was not completely effective in controlling mold growth in the hay baled at an average moisture content of about 28 percent. The control hay was judged to be slightly higher in quality on the basis of chemical composition after storage (Table 1). In the months after harvest, protein content of the control hay tended to be slightly higher and acid detergent fiber lower than in the acid-treated hay. Around 12 percent of the protein was present in lignified nitrogen form, which is a measure of the amount of protein expected to be relatively indigestible. The amount of protein in this form in the two hays did not differ greatly, indicating little or no difference in heat damage.

Intakes of grain and hay were similar, in keeping with the plan for a 50:50 concentrate to hay ration (Table 2). The control hay supported higher milk production than the other hay. Milk fat and non-fat solids percentages in the two groups were similar. Weight changes were minimal in both treatment groups.

There was very little difference between groups in the digestibility of ration components (Table 3). Digestibility values for the total ration were lower than desired for rations fed to lactating dairy cows. The alfalfa hay available for the experiment was in a more advanced stage of maturity than desired. Nevertheless, digestibility values for the rations were in agreement with the production data, indicating that the control hay was of higher quality than that baled at higher moisture content with the preservative added.

Table 1. Composition of hay

Item	Month			
	June (windrow)	July	August	September
	(percent, dry basis)			
Crude protein				
Control	16.4	16.4	17.0	15.4
Treated	16.9	15.8	15.0	16.6
Acid Detergent fiber				
Control	38.0	38.4	36.0	42.5
Treated	36.8	44.0	44.4	42.6

Table 2. Responses of cows to experimental rations

Item	Control	Acid-treated
Feed DM intake		
Grain, lb/day	16.3	16.3
Alfalfa hay, lb/day	16.3	16.5
Milk production		
Yield, lb/day	37.0	35.9
Fat test, percent	3.67	3.69
Non-fat solids, percent	8.58	8.54
SCM, lb/day	34.3	33.4
Weight change, lb/6 wk	6.3	10.9

Table 3. Digestibility of ration components

Component	Hay group	
	Control	Acid-treated
	(percent)	
Dry matter	56.4	55.6
Protein	64.2	63.7
Organic matter	60.1	59.2
Acid detergent fiber	21.9	25.2

The commercial acid product used in this trial was not effective in preserving hay quality. The ultimate goal in using hay preservatives would be to harvest hay at high moisture content and maintain quality equal to that obtained in hay baled under ideal conditions. No improvement in feeding value due solely to addition of a preservative should be expected in such a comparison. The economic advantage that could result from using an effective hay preservative would be in preventing weather damage by earlier baling in some cases, or in preventing the leaf loss occurring when hay is too dry at baling.

In additional work now in progress, it has been demonstrated that another hay preservative, different from the one used in the trial described in this report, is effective in preserving hay baled at high moisture content.

Effect of Teat Dipping on Mastitis Infection in Dairy Cows at First Calving

L.J. Bush, P.B. Barto, and G.D. Adams

Story in Brief

Mastitis infection in first lactation cows is a problem in dairy herds. This trial was conducted to determine whether daily teat dipping of heifers prior to calving would reduce the incidence of infection at calving.

One-half of a group of heifers were teat dipped daily with an iodine preparation starting at least two weeks before anticipated calving date. Within four days after calving, and at midlactation, quarter milk samples were obtained for microbiological examination. In the group teat-dipped before calving, 16 quarters in 11 cows were infected with mastitis organisms, whereas 12 quarters in eight cows were infected in the control group. The types of organisms found were the same as those commonly involved in mastitis in this herd. Many of the infections present at calving were not evident by midlactation.

Teat dipping of heifers prior to calving did not affect the incidence of mastitis infection at calving.

Introduction

Significant progress has been made in recent years toward reducing the incidence of mastitis in dairy herds. By following recommended control procedures, a high percentage of new infections can be prevented. For example, the number of new infections occurring during lactation can be reduced by at least 50 percent by dipping of teats with an effective bactericidal preparation after each milking. Antibiotic infusion at drying off has proven to be an effective means of preventing approximately 75 percent of the new infections that would otherwise be expected to occur during the dry period.

Yet, in herds where the overall infection rate is relatively low, udders of a disporportionate number of first lactation cows contain mastitis organisms. In the OSU herd, these infections apparently existed at the time of calving, rather than being new infections occurring early in lactation. It appears likely that such infections represent a greater problem in dairy herds than generally recognized, because they are not as apt to result in clinical mastitis in young cows.

This experiment was conducted to determine whether daily teat dipping with an iodine preparation prior to calving would reduce the incidence of mastitis infection in first lactation cows at calving.

Materials and Methods

Sixty-four dairy heifers were paired on the basis of anticipated calving date, and by breed where feasible. There were 25 pairs with heifers of the same breed and seven pairs with different breeds. The experimental plan was for one member of each pair to serve as a control with no treatment, and the other to be teat dipped daily for at least two weeks prior to calving. Samples were not obtained from a few animals. Data were available on 28 teat-dipped heifers and 29 control heifers. The days of teat dipping prior to calving ranged from seven to 127, with an average of 36 days. An extended period for a few animals occurred because they were pasture bred and an accurate breeding date was not available. Only six heifers were teat-dipped less than two weeks prior to calving.

Duplicate quarter milk samples were taken within four days after calving and again at mid-lactation. These were plated on blood agar for determination of the number and type of bacteria present, using procedures outlined by the National Mastitis Council. Swabs on the exterior of the teats of several animals also were made to determine the types of organisms present prior to calving.

Results and Discussion

One-third of the heifers were found to be infected on the basis of microbiological examination of quarter milk samples within four days after calving (Table 1). Of the 19 having mastitis organisms in one or more quarters, only one was observed as a clinical case of mastitis by the time of sampling. In comparison, 25 percent of the infections were evident as clinical mastitis in previous work with older cows.

Teat dipping prior to calving was not effective in reducing the number of infections at first calving. The infections may have existed in the heifers before teat dipping was started, so that this practice had no effect on infection status. It is highly unlikely that the infections were acquired within four days after calving for a number of reasons. One factor supporting this opinion is that the overall level of infection in the herd was much lower than that found in the first lactation cows at this stage, i.e., approximately five percent vs. 12.3 percent of quarters infected. Also, recently calved cows are milked first in the OSU herd

Table 1. Infection status of cows at calving

Group	No. of cows		No. of quarters	
	Negative	Infected	Negative	Infected
Dipped	17	11	96	16
Control	21	8	104	12
	38	19	200	28

Table 2. Types of organisms in infected quarters at calving

Organism	No. of cows	No. of quarters
Staph. aureus	8	11
Strep, dysgalactiae	9	16
Strep. uberis	2	2
Other	3	3

Table 3. Comparison of infection status of cows at calving and at mid-lactation

Status at:		Group		
Calving	Mid-lactation	Dipped	Controls	Total cows
Neg.	Neg.	15	17	32
Neg.	Inf.	0	3	3
Inf.	Inf.	1	3	4
Inf.	Neg.	9	5	14
		25	28	53

reducing the probability that the infections were transmitted from older cows via the milking equipment.

The types of organisms found in the first lactation cows at calving were the same as those commonly found to cause mastitis in this herd (Table 2). Moreover, the same types of bacteria were found on the exterior of the teats of the heifers before calving.

A comparison of the infection status of cows at calving and at mid-lactation revealed that many of the infections were transitory in nature (Table 3). Of 18 cows infected at calving, five later became clinical cases, but with different quarters infected in two of them. Ten apparently recovered spontaneously, whereas four were still positive at mid-lacation. Also, three cows negative at calving were found to have mastitis-causing organisms in the udder at mid-lactation. Of 53 cows still in the herd at mid-lactation, seven were infected. Eleven of 212 quarters, or 5.2 percent, were affected. This was essentially the same level of infection as existed in the total herd of approximately 200 milking cows. Mastitis infection in first lactation cows remains a problem in dairy herds. Hopefully, some solution will result from additional research now underway.

Poultry Nutrition

Supplementing Market Broiler Rations with Lactobacillus and Live Yeast Culture

R.F. Burkitt, R.H. Thayer and R.D. Morrison

Story In Brief

An eight-week feeding trial was conducted to observe the effect that the addition of a lactobacillus supplement and/or a live yeast culture to a broiler ration had on feed consumption, body weight gain, efficiency of feed conversion, and degree of pigmentation. Four experimental rations were fed: the broiler ration unsupplemented; the broiler ration supplemented with lactobacillus; the broiler ration supplemented with live yeast culture; and the broiler rations supplemented with both lactobacillus and live yeast culture. The lactobacillus supplement and the live yeast culture, alone and in combination, were added at dietary levels of 2.5 percent, respectively, to a nutritionally well balanced broiler ration. Body weight and feed consumption were recorded weekly. At the end of eight weeks, 10 males and 10 females from each ration were dressed and scored on skin and fat pigmentation, and degree of fat deposition.

A field trial involving 30,000 broilers, in which the same lactobacillus supplement was used, was conducted concurrently to the eight-week feeding trial. The results from both feeding trials were essentially the same.

No significant differences in body weight gain among the broilers fed the four rations were observed at any time throughout the course of the eight-week feeding trial. However, feed consumption and efficiency of feed conversion, on a cumulative basis, were significantly lower for the broilers fed the lactobacillus supplemented rations during the first four weeks of the experiment. In addition, visual scoring of the dressed broilers indicated that degree of pigmentation was greater when lactobacillus was fed, and that both degree of pigmentation and amount of fat deposition were superior when a combination of lactobacillus and live yeast culture was used.

Although differences in body weight gain were not significant among the broilers which were fed the four experimental rations, it must be pointed out that the broiler ration which was selected and used was one which produced

maximum weight gains and a high efficiency of feed conversion under commercial feeding conditions. Further research will need to be conducted to determine if comparable results can be obtained with broiler rations which may be nutritionally marginal, and which are lower in cost.

Introduction

Broiler chickens are among the most efficient converters of raw feed nutrients into meat from both a nutritional and an economic standpoint when compared to other types of livestock. Modern advances in feed ingredient processing procedures, in the development of new feed ingredients, and in ration formulation have played an important role in bringing this about. However, increases in feed ingredient prices coupled with diminishing returns to the broiler producer during recent years have intensified the search, along these same lines, for additional ways and means of reducing ration cost or increasing efficiency of feed conversion or both.

Some micro-organisms have been shown to enhance the ability of the small intestine to absorb food nutrients by improving the environment within the intestinal tract, and, in so doing, to bring about an increase in efficiency of feed conversion. Lactobacillus, which falls into this category, has been stabilized in a beadlet form or inpregnated on a soybean oil meal carrier in a stabilized form, so that it can be used effectively to supplement rations for poultry, cattle, hogs, and dogs. It is theorized that once the stabilized micro-organism reaches the intestine it becomes active and multiplies. It replaces the so called harmful intestinal bacteria, and the overall condition of the intestinal tract is improved. As a result of this action, it is thought that nutrient digestion and absorption are enchanced, and food nutrients are utilized more efficiently. It is speculated that rations which contain relatively poor quality feed ingredients or those that are marginal from a dietary nutrient standpoint might be used with greater efficiency under these conditions.

Very few feeding trials have been conducted with lactobacillus supplemented rations in which modern commercial broiler rations, and the broiler breeds and crosses as they are bred today were used. There is a growing interest in this type of product for use in Oklahoma and Arkansas, and research data on growth performance are needed.

The purpose of this feeding trial was to determine the nutritive value of a lactobacillus supplement when added to a standard broiler ration currently being used under commercial growing conditions. A live yeast culture was included since research work at Oklahoma State University has shown the value of this product in improving efficiency of nutrient utilization in broiler rations. An eight-week feeding period was utilized although it is recognized that broilers are usually marketed at an earlier age. Data were collected on growth performance at weekly intervals which permitted a comparative evaluation to be made at ages younger than eight-weeks.

Materials and Methods

A total of 1200 Cornish x White Rock broilers (600 males and 600 females) were randomly assigned to 40 floor pens (6 x 12 feet) with 30 males or 30 females in each of 20 pens. Management procedures during the eight-week growing period were similar, insofar as possible, to those currently recommended under commercial production conditions.

The standard commercial broiler rations which were used consisted of a starter ration (24 percent protein), and a finisher ration (22 percent protein). The starter ration was fed during the first four weeks of the feeding trial, and the finisher ration the final four weeks. Both of these rations conformed to nutrient requirements as recommended for use in commercial broiler rations. The formulas are given in Table 1.

Four experimental rations were formulated from these commercial rations and were fed with five pens of males and five pens of females, each receiving one of the four rations. Ration 1 served as a control and was not supplemented with either the lactobacillus supplement or live yeast culture. Rations 2, 3, and 4 were supplemented with live yeast culture, lactobacillus, and a combination of the two, respectively. A dietary level of 2.5 percent was used for each ingredient whether it was used singly or in combination. The lactobacillus was added to the ration in the form of a supplement that utilized

Table 1. The commercial broiler starter and finisher rations which were modified in the formulation of the four experimental rations fed in the eight-week feeding trial

Ingredients	Starter (percent)	Finisher (percent)
Tallow, feed grade	5	5
Corn, ground yellow	39.35	45.25
Milo, ground	14.6	14.1
Soybean oil meal (44%)	29	25
Fish meal (menhaden)	4	4
Feather meal	2	2
Meat and bone scrap (50%)	4	2.5
dl Methionine	0.15	0.12
Phosphorus supplement (Ca 31-P 18)	0.6	0.7
Calcium carbonate	0.5	0.5
Salt	0.3	0.3
Trace mineral mix[1]	0.1	0.1
Vitamin supplement[2]	0.3	0.3
Choline choride - 50	0.07	0.07
Coban[3]	0.1	0.1
Florafil[4]	0.0	0.0012

[1]Provides in the mixed feed: Manganese 120 ppm, Zinc 80 ppm, Iron 60 ppm, Copper 10 ppm, and Iodine 1 ppm.
[2]Contains per pound of vitamin mix: Vitamin A 1, 600,000 I.U., Vitamin D_3 600000 I.U., Vitamin E 3400 I.U., Riboflavin 1000 mg., Niacin 3000 mg., Pantothenic Acid 3200 mg., Choline 80,000 mg., Menadione 400 mg., Folic Acid 200 mg., Thiamin 436 mg., Pyridoxine 486 mg., Biotin 20 mg., and Vitamin B_{12} 1.6 mg.
[3]A coccidiostat.
[4]A marigold petal extract of xanthophylls.

soybean oil meal as a carrier. The lactobacillus supplement replaced an equivalent amount of soybean oil meal, and the live yeast culture an equivalent amount of ground corn.

Feed consumption and body weight were recorded at weekly intervals on a per pen basis. At the termination of the experiment, two broilers from each of the 40 pens were selected at random and New York dressed. This procedure provided 10 males and 10 females from each of the four rations or treatments. Each of the eight groups (10 males or 10 females) were visually scored for pigmentation and fat deposition. Appropriate statistical analyses were applied to the data (both weekly and cumulative) involving the response variables of body weight, body weight gain, feed consumption, and units of feed per unit of gain.

A field trial was conducted concurrently with the eight-week feeding trial. This field trial involved two broiler houses which were divided into two pens each with a broiler capacity of 7500 broilers per pen. Two pens of broilers were fed an unsupplemented broiler ration, while the broilers in the other two pens were fed the broiler rations supplemented with lactobacillus. The broiler lines which were used were K_2xY and K_2xT_1 from Peterson Farms, Inc. Records were kept on mortality, total body weight, feed consumption, and dressed market grades. Calculations were made to determine percent mortality, average body weight, feed conversion, feed efficiency, and feed cost per broiler. The field trial covered a feeding period of 52 days from September 30, 1976 through November 21, 1976.

Results and Discussion

Data on body weight in pounds, and pounds of feed consumed per pound of body weight at weekly intervals during the eight-week feeding period are presented in Tables 2 and 3, respectively. There was no statistically significant

Table 2. Body weight by weeks in pounds

Ration number	Sex	1	2	3	4	5	6	7	8
1 Unsupplemented	Males	0.30	0.69	1.20	1.92	2.68	3.49	4.39	5.35
	Females	0.29	0.63	1.09	1.68	2.29	2.95	3.62	4.26
2 + live yeast culture	Males	0.30	0.69	1.22	1.92	2.70	3.52	4.37	5.25
	Females	0.29	0.63	1.08	1.67	2.27	2.93	3.58	4.20
3 + lactobacillus	Males	0.29	0.68	1.20	1.90	2.68	3.51	4.34	5.28
	Females	0.29	0.65	1.10	1.68	2.29	2.95	3.61	4.27
4 + live yeast culture and lactobacillus	Males	0.30	0.69	1.20	1.93	2.72	3.57	4.42	5.26
	Females	0.28	0.62	1.07	1.65	2.26	2.90	3.54	4.19
LSD		± 0.01	0.02	0.03	0.04	0.05	0.08	0.11	0.14

Table 3. Efficiency of feed conversion in pounds of feed per pound of body weight by weeks

Ration number	Sex	1	2	3	4	5	6	7	8
1 Unsupplemented	Males		1.49	1.62	1.73	1.85	1.98	2.08	2.17
	Females		1.56	1.65	1.79	1.91	2.06	2.18	2.33
2 + live yeast culture	Males		1.51	1.60	1.69	1.81	1.94	2.06	2.18
	Females		1.55	1.65	1.77	1.90	2.05	2.18	2.23
3 + lacotbacillus	Males		1.47	1.57	1.69	1.80	1.93	2.07	2.18
	Females		1.51	1.63	1.77	1.91	2.04	2.19	2.33
4 + live yeast culture and lactobacillus	Males		1.47	1.59	1.69	1.84	1.95	2.07	2.21
	Females		1.50	1.63	1.75	1.89	2.03	2.17	2.32
LSD		±	0.05	0.04	0.03	0.04	0.03	0.04	0.05

differences in body weight among the broilers fed the four experimental rations.

On the basis of pounds of feed required per pound of gain during any given week, there were no statistically significant differences in the efficiency with which the four rations were utilized. However, the cumulative values for pounds of feed per pound of broiler when compared at the end of the second, third, and fourth weeks of the growing period indicated that the broilers, as a group, which were fed Rations 3 and 4 (supplemented with lactobacillus) required significantly ($p<0.05$) less feed per pound of meat produced than did the broilers, as a group, which were fed Rations 1 and 2 (no lactobacillus). The greatest efficiency of feed conversion came during the first two weeks with a gradual decrease taking place during weeks three and four. Thus it appears likely that the benefit derived from the feeding of the lactobacillus in terms of increased efficiency of feed conversion comes during the early part of the growing period from day-old through the fourth week.

It must be pointed out, however, that the commercial broiler rations which were fed produce body weight gains and efficiencies of feed conversion which compare favorably with the best growth performance obtained under commercial production conditions. Perhaps from the standpoint of the nutritional adequacy of these rations, and from the growth potential of the broiler cross which was used, very little improvement in growth performance could be expected. It has been suggested that the results might have been different if rations with marginal dietary nutrient levels and lower ingredient cost had been used. Further feeding trials will have to be conducted to determine if this line of reasoning is valid.

The relative degree of pigmentation and fat deposition among the broilers fed the four experimental rations is summarized in Table 4. Lactobacillus brought about the greatest degree of pigmentation in both males and females, but did not produce maximum fat deposition. The females fed a combination

Table 4. Comparison of fatness and pigmentation scores among the broilers fed the four experimental rations

Ration number	Sex	Color	Fatness
1 Unsupplemented	Males	3	3
	Females	3	3
2 + live yeast culture	Males	4	4
	Females	4	4
3 + lactobacillus	Males	1	2
	Females	1	2
4 + live yeast culture and lactobacillus	Males	2	2
	Females	1	1

Scores range from 1 through 4 for both color and fatness; 1 denotes deep yellow color or good fat covering; 4 denotes pale yellow color or relatively poor fat covering.

of lactobacillus and live yeast culture were superior in both color and fatness. It should be pointed out that the broilers fed Ration 2 were relatively well covered with fat, and rated a score of 4 only on the basis of a comparision with the other three groups. It is possible that the deeper color in the broilers fed Rations 3 and 4 may have led the grader to score them higher on fat deposition. It can be concluded that lactobacillus produces a superior degree of pigmentaion, and in combination with live yeast culture gives a distinct advantage insofar as color and finish are concerned on a grade basis.

Data from the field trial are summarized in Table 5. There were no differences in growth performance among the broilers fed the two rations. However, it was noted that on a pigmentation basis the broilers fed the lactobacillus had a much deeper color. The opinion was expressed by the processor, that for this reason, these broilers might bring a premium on eastern markets. This production of a greater degree of pigmentation by the lactobacillus is in line with the results which were obtained in the eight-week feeding trial. Feed conversion on a pound of feed per pound of broiler basis in the field trial was probably lower with the lactobacillus fed broilers early in the growing period, as it was in the eight-week feeding trial, but it had disappeared by the time the broilers were marketed.

Further research needs to be done in order to determine the value of lactobacillus, live yeast culture, and a combination of these two feed ingredients in low cost broiler rations. At the present time the primary advantage in using a lactobacillus supplement appears to be in promoting pigmentation. The value of live yeast culture in relation to phosphorus utilization has been reported previously.

Table 5. Summary of the data obtained in the 52 - day field trial

Pen	Line	Number broilers	Mortality (percent)	Total body weight (lbs.)	Average body weight (lbs.)	Feed cons. (lbs.)	Feed conv. (lbs.)	Feed eff. (lbs.)	Feed cost per lb. broiler (cents)	Grades (percent) A	B	C
				Unsupplemented								
NE	$K_2 \times Y$	7,314	2.48	31,020	4.24	63,000	49.24	2.03	15.15	62.0	9.2	24.6
NW	$K_2 \times T_1$	7,295	2.73	29,850	4.09	60,190	49.59	2.01	15.09	65.0	8.6	22.5
NE & NW		14,609	2.61	60,870	4.17	123,190	49.42	2.02	15.12	63.5	8.9	23.6
				Supplemented								
SW	$K_2 \times Y$	7,295	2.73	30,380	4.16	62,260	48.80	2.04	15.31	62.8	8.4	24.5
SE	$K_2 \times T_1$	7,293	2.76	29,940	4.10	60,090	49.83	2.00	15.03	63.2	9.1	23.7
SE & SW		14,588	2.75	60,320	4.13	122,350	49.32	2.02	15.17	63.0	8.8	24.1

Meat and Carcass Evaluation

Estimates of Bone Maturity in Beef Cattle

J. J. Guenther

Story in Brief

The progress of long bone maturation was followed in Hereford and Charolais crossbred steers, slaughtered at 500, 700, 900, and 1100 pounds by measuring the metacarpal epiphyseal cartilage thickness, and by determining the activity of serum alkaline phosphatase enzymes. Results showed a significant decrease in metacarpal epiphyseal cartilage thickness, and in serum alkaline phosphatase activity with increased weight and age of the test animals. Data suggest a positive relationship between the ossification of the metacarpal epiphyseal cartilage and the decline in serum alkaline phosphatase activity.

Introduction

Apparently, muscle tissue in beef cattle does not attain its maximum growth rate, regardless of nutritional level, until bone approaches its physiologically mature state. Thus an estimate of the state of bone maturity could be useful to beef producers; for this would let producers identify the time at which it would be most beneficial to full-feed cattle for maximal rate of muscle growth.

Growing epiphyseal cartilage is one of the pre-requisites for long bone growth. When this cartilage becomes ossified the bone is "physiologically mature," increases in long bone length cease, and the stature or scale of the animal is fixed. The progress of bone maturation may be followed by measuring the width of the epiphyseal line, which narrows as the epiphyseal cartilage ossifies. In addition, it is thought that much of the alkaline phosphatase enzyme activity in serum is generated from osseous sources. Bone forming cells apparently secrete this enzyme which influences the deposition of calcium in bone tissue. Consequently, when bone growth nears its mature stage, a decline in the activity of serum alkaline phosphatase should occur.

The objectives of this experiment were to determine changes in metacarpal epiphyseal cartilage thickness and in serum alkaline phosphatase activity with increased weight in cattle.

Materials and Methods

Sixteen Hereford and 16 Charolais crossbred steer calves were used in the text. Four calves from each breed were assigned to one of the following slaughter weight groups: 500, 700, 900, and 1100 pounds. All calves were fed, *ad libitum*, a standard feed-lot ration until attaining the desired slaughter weight.

Epiphyseal cartilage measurements

The right metacarpal bones were removed from the carcass, freed of extraneous material, and six, one-fourth inch thick slices were obtained from the distal epiphysis of the bones. The bones were sliced to a point one inch dorsal to the epiphyseal line. Bone samples were prepared for epiphyseal cartilage measurement following a procedure modified from that of Evans, *et. al.* (Endocrinology, 32:13). Three measurements, evenly spaced (anterior-posterior), were obtained on each face (lateral and medial) of the bone slices using a light microscope fitted with an ocular micrometer.

Serum alkaline phosphatase activity

Blood samples were obtained at slaughter. The samples were collected in 50 ml. centrifuge tubes, allowed to clot at room temperature for 24 hours, then centrifuged for 30 minutes at 5000XG. The serum fraction was decanted and serum alkaline phosphatase activity was determined via the procedure of Bessey, *et. al.* (J.B.C. 164:321).

Results and Discussion

Test results are presented in Table 1. There was a decrease ($P<0.01$) in metacarpal epiphyseal cartilage thickness with increased weight and age of the

Table 1. Effect of breed and weight on metacarpal epiphyseal cartilage thickness and serum alkaline phosphatase activity

Breed	Weight group	Metacarpal epiphyseal cartilage thickness	Serum alkaline phosphatase activity[2]
Hereford	500 lbs	713	5.97
	700 lbs	589	5.78
	900 lbs	649	4.06
	1100 lbs	494	3.23
Charolais	500 lbs	657	5.78
Crossbred	700 lbs	632	7.33
	900 lbs	614	4.90
	1100 lbs	574	4.30

[1]Thickness measurements are in microns and each number represents the group average.
[2]Activity is presented in Sigma Units and each number represents the group average.

experimental animals. The overall decrease was greater for the Herefords, 219 μ, than for the Charolais crossbreds, 83 μ, suggesting that the Herefords were earlier maturing in long bone growth than the crossbreds.

Serum alkaline phosphatase activity data followed the same general trends as did the metacarpal epiphyseal cartilage measurements, showing a decrease ($P<0.01$) with animal weight and age. The overall drop in serum alkaline phosphatase activity from the 500 pound to the 1100 pound weight groups was 1.85 times greater, on the average, for the Hereford steers.

Results from this test suggest that with refined techniques for obtaining blood samples, serum alkaline phosphatase activity might be used as a non-destructive procedure on live cattle to estimate the state of physiological maturity of bone in beef cattle. Further testing, starting with younger cattle of known chronological age, and selected for this type of study seems warranted.

The Effect of Electrical Stimulation on the Rate of Post-Mortem Glycolysis in Some Bovine Muscles

P.D. McCollum and R.L. Henrickson

Story in Brief

Processing beef prior to the onset of rigor results in an unsatisfactory product. Electrical stimulation will hasten rigor by accelerating post-morten metabolism. The purpose of this manuscript is to describe the effect of electrical stimulation on the rates of post-mortem glycolysis in the choice bovine carcass.

Sides from six choice carcasses weighing 310 - 367 Kg. were stimulated for 30 minutes beginning an hour after death. Sides from seven carcasses were stimulated for 15 minutes beginning 30 minutes post-mortem. In each instance the opposite side from the same carcass was held as an unstimulated control. All electrical parameters were held constant in all stimulated sides. Samples were taken from the longissimus dorsi (LD), psoas major (PM),

semimembranosus (SM), and supraspinatus (SS) muscles of all sides. The pH was estimated at 0.5, 1,2,4,6,8,12, and 24 hours post-mortem.

Significant ($P<0.05$) differences were found in the rate of pH decrease between corresponding muscles of stimulated and unstimulated sides, except in the case of the PM.

Introduction

With the realization that post-mortem carcass treatments exert the greatest influence on beef palatability, and for a number of economic reasons, this research was directed toward establishing a method to hasten the post-mortem changes that convert muscle to meat. Muscle from freshly slaughtered animals, if prepared and consumed immediately, will produce tender meat. As the inherent supplies of adenosine triphosphate (ATP) and its precursors are depleted, the muscle becomes inextensible, and tenderness is at its low ebb. This change is temperature dependent, proceeding faster at elevated temperatures. Aging the bovine carcass by conventional chilling methods at temperatures of 0 - 2° C for 10 - 14 days has, in the past, been regarded as necessary to allow autolytic and bacterial enzymes to partially digest the meat to obtain a state of satisfactory tenderness.

Recently there has arisen some interest in the use of electrical stimulation to accelerate the rate of post-mortem muscle metabolism and the development of associated palatability characteristics. Originally conceived as a method of tenderization, carcass stimulation has hastened ATP depletion and pH drop in chicken; increased glycolytic rates in *Rana*, and rabbit; hastened post-mortem glycolysis, prevented cold shortening, and increased tenderness in lamb; and improved tenderness and flavor in beef.

Materials and Methods

Thirty-minute stimulation

Six hereford heifers ranging from 310 to 367 Kg. were delivered to the Meat Science Abattoir 24 hours prior to slaughter. The heifers were slaughtered, dressed, and split according to normal practices. The sides, weighing from 94 to 114 Kg were then removed to a 16° C room. One side from each carcass was designated as the stimulated side and was connected to a pulse generator via two leads. One lead was a set of eight stainless steel shroud pins connected by a copper wire and spaced by a teflon band, and was inserted into the muscles of the round. The other lead was connected to three similar pins which were inserted into holes drilled in the third, fourth, and fifth cervical vertebrae.

Stimulation was initiated one hour after death and continued for 30 minutes. The pulse generator delivered a direct current square wave pulse, with a frequency of 400 cycles per second, and a duration of 0.5 miliseconds.

Voltage was rapidly increased to 300 volts and remained at this level until stimulation was concluded.

Four hours after death, muscles were dissected from the carcass and removed to a 1.1° C cooler for the duration of the experiment.

Fifteen-minute stimulation

Two steers and five heifers of approximately the same grade (choice) were slaughtered in the conventional manner. The live weights of these animals ranged from 363 to 447 Kg., and side weights were from 122 to 140 Kg. The electrical stimulation procedure was the same as for the previous group, except it was initiated at 30 minutes post-mortem and was continued for 15 minutes. Muscles were dissected and removed to the cooler at two hours post-mortem.

Sampling and pH estimation

Just before the electrical stimulation was initiated, 0.5 inch cores were removed from the longissimus dorsi at the level of the tenth rib; from the semimembranosus at an area two inches posterior to the posterior border of the symphysis pubis; from the medial third of the supraspinatus; and in the case of the thirty minute stimulation period, from the anterior third of the psoas major.

These samples were weighed and homogenized in ten volumes of doubly distilled water. The homogenates were then estimated by a pH meter fitted with a combination electrode. Subsequent samples were taken at 2, 4, 6, 8, 12, and 24 hours post-mortem.

Results and Discussion

Thirty-minute stimulation

Results of the 30-minute stimulation are shown in Table 1. Before stimulation, the pH of the corresponding muscles from each side was not significantly different. Following stimulation, the longissimus dorsi and the semimembranosius exhibited significantly ($P<0.05$) lower pH readings in the stimulated muscles. In the case of the LD, there was no significant difference in pH after 24 hours as the control had fallen to its ultimate level. There was no significant change in the pH of the stimulated LD after six hours.

Differences between SM muscles from stimulated and control sides remained significant throughout the sampling period, the control muscles did not arrive at their ultimate pH within 24 hours.

The PM showed no treatment difference in pH at any of the sampling periods. This implies that electrical stimulation did not increase the rate of post-mortem glycolysis in this muscle. This assessment is contradictory to the findings of Davey *et.al.* (J. Agric. Res. 19:13) who found accelerated pH decline in the PM of stimulated beef sides. The primary difference between the two

Table 1. Muscle pH from control and stimulated sides at each sampling period. Stimulation initiated at one hour post-mortem and continued for 30 minutes

Hr. post-mortem	L. Dorsi		P. Major		Semimembranosus		Supraspinatus	
	Control	Stimulated	Control	Stimulated	Control	Stimulated	Control	Stimulated
1	6.74±.12	6.68±.12	6.22±.15	6.20±.19	6.76±.14	6.77±.06	6.65±.14	6.66±.16
2	6.62±.21	6.18±.10[1]	6.00−.22	5.96−.17	6.56±.28	6.22±.09[1]	6.56±.22	6.34±.14
4	6.31±.24	5.77±.31[1]	5.56±.22	5.64±.14	6.51±.12	6.02±.15[1]	6.34±.10	6.02±.14[1]
6	6.07±.15	5.50±.19[1]	5.47±.19	5.55±.15	6.25±.23	5.82±.23[1]	6.04±.22	5.86±.19
8	5.87±.26	5.42±.17[1]	5.35±.14	5.34±.10	6.20±.14	5.43±.14[1]	5.89±.18	5.78±.15
12	5.68±.12	5.37±.06[1]	5.38±.07	5.34±.04	5.86±.30	5.34±.09[1]	5.88±.22	5.68±.21
24	5.39±.08	5.33±.04	5.35±.05	5.35±.04	5.51±.12	5.26±.06[1]	5.80±.26	5.63±.20

[1]denotes significant ($P<0.05$) difference between stimulated and control means for a muscle at a sampling period.

Table 2. Muscle pH from control and stimulated sides at each sampling period. Stimulation initiated at 30 minutes post-mortem and continued for 15 minutes

Hr. post-mortem	L. Dorsi		Semimembranosus		Supraspinatus	
	Control	Stimulated	Control	Stimulated	Control	Stimulated
½	6.74±.15	6.73±.12	6.85±.12	6.85±.12	6.79±.15	6.85±.16
1	6.65±.22	6.28±.13[1]	6.78±.12	6.30±.06[1]	6.72±.15	6.29±13[1]
2	6.43±.12	5.29±.13[1]	6.48±.09	6.06±.12[1]	6.58±.17	6.08±.18[1]
4	6.17±.31	5.43±.21[1]	6.30±.16	5.68±.19[1]	6.32±.11	5.77±.17[1]
6	5.99±.22	5.26±.07[1]	6.09±.25	5.40±.18[1]	6.08±.11	5.59±.16[1]
8	5.86±.28	5.35±.05[1]	5.96±.27	5.42±.17[1]	6.08±.15	5.57±.13[1]
12	5.73±.21	5.35±.10[1]	5.90±.30	5.33±.16[1]	5.92±.19	5.58±.22[1]
24	5.46±.15	5.34±.14	5.45±.14	5.32±.04[1]	5.71±.13	5.57±.18

[1]denotes significant ($P<0.05$) difference between stimulated and control means for a muscle at a sampling period.

studies was the electrical considerations, Davey *et. al.* used a greater voltage and a slower frequency.

Carse (J. Food Tech. 8:163) concluded that voltage, but not frequency, exerts an influence on the rate of post-mortem glycolysis. He showed that glycolytic metabolism is accelerated with increased voltage from 0 to 250 V. Bendall (J. Sci. Food Agric. 27:819), however, maintained that very high voltages are unnecessary to obtain the optimum rate of pH fall.

Clearly the source of the discrepancy is the psoas major itself, as the other muscles examined in this study gave results comparable to those found in the literature. The positioning of this muscle, the stretching it receives when the carcass is suspended, the amount of connective tissue it contains or surrounding depositions of fat may make the psoas major unsuitable for this type of study.

The supraspinatus from stimulated sides differed in pH from the unstimulated controls only at the four hour post-mortem sampling period. This muscle, located in the forelimb, is not in the direct path of the stimulating current and may not have received the degree of stimulation to which the other muscles were subjected.

Fifteen-minute stimulation

Results from the 15-minute stimulation are shown in Table 2. All muscles showed nonsignificant differences in pH between sides before stimulation. The stimulated LD reached its ultimate pH within four hours post-mortem, while its unstimulated control required 24 hours.

The semimenbranosus from this stimulation period showed the same pattern observed for the 30-minute stimulation. The control sides did not exhibit a pH drop comparable to the stimulated sides at the end of the 24-hour period.

The supraspinatus responded, to a greater degree in this study, than in the proceeding one. Since the stimulation was started at 30-minutes post-mortem, the musculature would be expected to have a greater glycogen supply at the initiation of stimulation than the group whose stimulation started at one-hour post-mortem. Thus, being in a "fresher" state may have attributed to the differences observed in the supraspinatus of the two stimulation groups.

The reduction of stimulation time from 30 to 15 minutes did not adversely affect the rate of pH decline in the stimulated sides.

Conclusions

This study confirms previously published conclusions that electrical stimulation is an excellent method of increasing post-mortem metabolism and quickly initiating the rigor process. Such a process has been shown to preclude the dangers of cold shortening and thaw contracture.

Work is under way to determine the feasibility of removing muscles from stimulated sides quickly post-mortem. This approach has advantages in streamlining slaughter and fabrication operations, a reduction in required cooler space, and the associated energy requirement.

Although electrical stimulation seems a practical method for hastening rigor, muscles in deep rigor do not exhibit satisfactory tenderness. Other research is required to establish methods to quickly age this meat to achieve a satisfactory end product.

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Reproduction Physiology

Recovery of Normal Semen Quality after Heat Stress of Boars[1]

R.P. Wettemann, M.E. Wells, L.W. Brock, R.K. Johnson, R. Harp and R. Vencl

Story in Brief

When six Yorkshire boars were subjected to 94°F ambient temperature, sperm motility was decreased compared to six control boars at 74°F. After heat stressed boars were returned to 74°F, sperm motility did not return to normal values until after about five weeks of cool temperature. The reduction in semen quality was associated with a reduction in fertility. Conception rate was decreased when gilts were bred to heat stressed boars, but embryonic survival was not influenced.

Providing boars with only shade during the summer caused increased respiratory rates and decreased semen quality. If sprinklers were available for boars in addition to shade, respiratory rates and semen quality were similar to those for boars maintained in cool chambers. An additional year of study is necessary to determine possible year differences and to obtain sufficient semen quality and fertility data to evaluate these management methods.

Introduction

Reproductive efficiency is reduced when swine are mated during the summer months. Results of recent studies indicate that breeding problems during the summer months may be the result of heat stress on boars as well as on gilts. Formation of sperm is a continual process, requiring about five or six weeks in most males. If sperm are affected in the formation stages by increased body temperature, the influence may be apparent several weeks later.

The purposes of these experiments were to determine the interval from the end of heat stress to normal sperm production and to evaluate management systems which should reduce heat stress of boars.

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In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

Experimental Design

Experiment 1

Six Yorkshire boars of proven fertility were allotted to each of two temperature controlled chambers. After a three-week adjustment period at 74°F, control boars were maintained at 74°F and heat stressed boars were exposed to 88°F from 5 pm to 9 am, and 94° from 9 am to 5 pm. Feed intake was controlled and boars gained about 0.5 pounds/day. Boars were ejaculated twice weekly and semen quality was evaluated weekly starting three weeks prior to treatment through the sixth week of heat stress.

From day 40 through day 75 of treatment, control and heat stressed boars were mated to a total of 77 gilts. Gilts were slaughtered at day 30±3 of pregnancy and conception rate and the numbers of corpora lutea and normal embryos were determined. After 75 days of heat stress all boars were exposed to 74°F daily for six weeks. Boars were ejaculated twice weekly and semen quality was evaluated weekly.

Experiment 2

Eighteen boars were used in this trial during May through October, 1976. Six boars were housed in a temperature controlled chamber at approximately 70°F. A second group of six boars was kept in outside lots with a shade provided and a third group of six boars was kept in outside lots provided with shade and a water sprinkler from June 1 until September 15. Maximum and minimum ambient temperatures were recorded daily under the shade at 3 pm and respiratory rates were determined three times each week. Sperm motility and morphology were evaluated during the first weeks of June, August and October.

Results

Experiment 1

The quality of the sperm cells was reduced by heat stress. In Figure 1, percent motile sperm from heat stressed boars is compared to that for control boars. During the three weeks prior to heat stress, percent motile sperm was similar in both groups of boars (averaged 80 percent). After two weeks of treatment, motile sperm decreased to 56 percent in stressed boars. During the third to sixth weeks of treatment, only half as many motile sperm were obtained from heat stressed boars as from control boars.

After the five-week breeding period, heat stressed boars had 53 percent motile sperm, whereas control boars had 85 percent (Figure 1). Stressed boars were then exposed to a cool temperature (74°F). Percent motile sperm gradually improved, and after five weeks, percentages of motile sperm were similar for stressed and control boars. Therefore, if sperm are affected in the formation

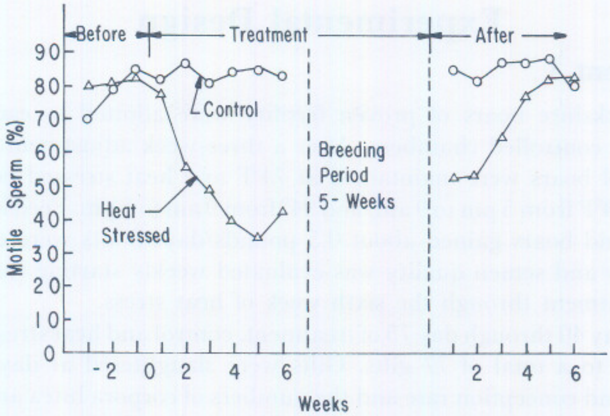

Figure 1. Motility of sperm from control and heat stressed boars before, during and after exposure to elevated ambient temperature.

stages by increased body temperature due to heat stress, the influence is present for up to five weeks later.

Fertility was reduced when gilts were mated to boars after six weeks of heat stress (Table 1). Eighty-two percent of the gilts bred to control boars conceived, but only 59 percent of the gilts bred to heat stressed boars were pregnant. Embryonic survival at 30 days after breeding was similar for gilts bred to control or heat stressed boars. Gilts that were bred to control boars had an average of 10.9 embryos, and gilts bred to heat stressed boars had 10.7 embryos. The reduction in fertility in this study is similar to that which was observed in a previous experiment when gilts were artifically inseminated with semen from heat-stressed boars.

Experiment 2

The temperature in the cool chamber ranged from 55 to 75°F during the trial (Figure 2). Ambient temperature, in El Reno, increased from an average weekly maximum of about 83°F, during the last two weeks of May, to 104°F during the second week of August. Then the maximum temperature decreased gradually to about 79°F during the first week of October.

Table 1. Fertility of gilts bred to control or heat stressed boars

			Gilts pregnant at 30±3 days after breeding		
Treatment	No. of boars	No. of gilts bred	No.	Percent	Embryo survivial (percent)
Control	6	37	30	82.3	82.1
Heat Stressed	6	40	25	59.2	82.1

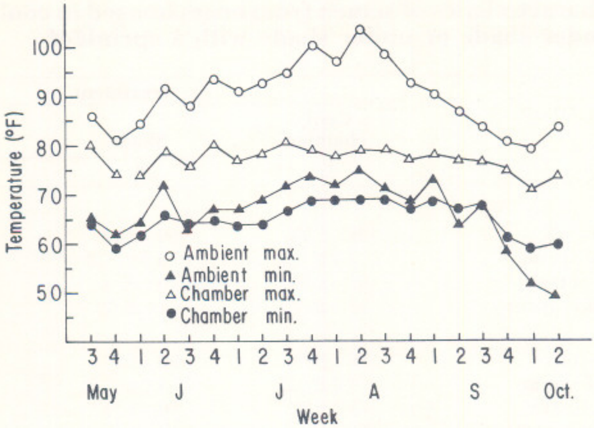

Figure 2. Maximum and minimum ambient and environmental chamber temperatures that boars were exposed to during 1976.

The respiratory rates (RR) of the boars were directly related to the ambient temperature (Figure 3). When boars are exposed to elevated ambient temperature, increased evaporative cooling by the respiratory passages is a major way excess heat is removed from the body. During the last two weeks in May and the first week in June, RR were similar in all boars. As ambient temperature increased, RR increased rapidly in boars provided with only shade, reaching a maximum of 144 breaths per minute in August. During

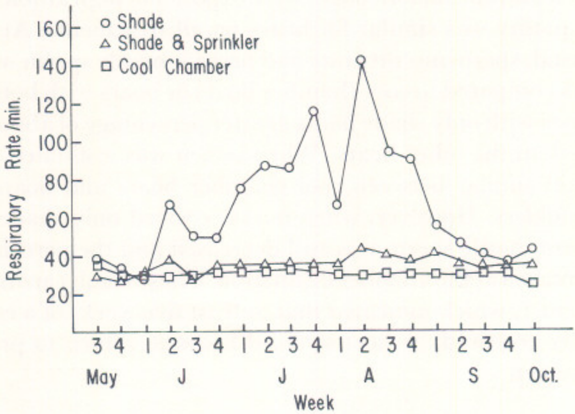

Figure 3. Respiratory rates of boars maintained in cool chambers, under shade or under shade with a sprinkler.

Table 2. Characteristics of semen from boars housed in cool chambers, under shade or under shade with a sprinkler

	Treatment		
	Cool chamber	Shade	Shade + sprinkler
No. Boars	**5**	**6**	**6**
June 1976			
Semen volume (ml)	138 ±39	159 ±15	142 ±41
Motility rate of sperm	3.7± .2	3.5± .2	3.8± .1
Percent motile sperm	67 ± 4	70 ± 4	78 ± 2
Percent abnormal sperm	13 ± 2	11 ± 2	12 ± 2
August 1976			
Semen volume (ml)	126 ±23	129 ±29	181 ±25
Motility rate of sperm	3.3± .2	3.1± .1	3.5± .1
Percent motile sperm	75 ± 4	56 ± 4	76 ± 2
Percent abnormal sperm	8 ± 1	19 ± 2	10 ± 1
October 1976			
Semen volume (ml)	112 ±30	156 ±21	186 ±40
Motility rate of sperm	3.5± .2	2.8± .1	3.5± .1
Percent motile sperm	69 ± 2	55 ± 2	70 ± 3
Percent abnormal sperm	11 ± 2	17 ±1	11 ± 2

August, for boars supplied with sprinklers as well as shade, RR was only slightly greater than that for boars in the cool chamber. These results indicate that boars given only shade were heat stressed, but if sprinklers were supplied the stressful effect of high ambient temperature was greatly reduced.

Similar to previous studies, semen volume was not influenced by heat stress (Table 2). Although boars were not trained for semen collection on a dummy, it was possible to obtain ejacula from 17 of the 18 boars at each of the collection times. In June, before boars were exposed to high ambient temperatures, semen quality was similar for boars on all treatments. At the August evaluation period, sperm motility rate and percent motile sperm were reduced for shade boars compared to cool chamber boars or boars with both shade and sprinklers. Boars with only shade had a greater percentage of abnormal sperm in the ejacula than the other boars. When semen was evaluated in October, quality was still similar between cool chamber boars and boars with both shade and sprinklers. However, when boars received only shade during the summer, percent motile sperm was still decreased and the percent abnormal sperm was increased at the October evaluation. These results are in agreement with Experiment 1, which indicated that at least five weeks of a cool ambient temperature are required for heat stressed boars to return to production of high quality semen.

Ovarian Response of Angus Cows to PMS Treatments for Two Consecutive Years[1]

E.J. Turman, R.P. Wettemann, M.P. Fournier and J.G. MaGee

Story in Brief

Ovarian response to PMS in 11 Angus cows that had not previously been injected with PMS was compared to the response in 10 Angus cows that had received a single injection of 2000 IU PMS the previous year. Both groups were given 1500 IU PMS on day five plus 2000 IU PMS on day 17 of the estrous cycle. Eleven control Angus cows were injected with saline.

Only five cows in each of the PMS groups were observed in heat following the day 17 PMS injection compared to nine of 11 control cows. The interval from the second PMS injection to the onset of heat was 1.8 days longer in the cows that had been previously injected with PMS. However, the major difference between the two PMS treated groups was in degree of superovulatory response. Average ovulation rates were 5.5 for the cows never previously treated compared to 2.3 for the cows that had previously received PMS. Eight of the 10 cows previously injected with PMS were not superovulated, having only a single or no ovulation compared to four of the 11 cows that were receiving PMS for the first time.

Although the differences were not statistically significant, the trends observed in these data suggest that PMS injections one year may adversely affect the superovulatory response of cows to subsequent PMS injections.

Introduction

Research conducted at the Oklahoma Agricultural Experiment Station since 1968 has demonstrated that it is possible to greatly increase the incidence of multiple births in beef cows by means of hormone injections. Approximately one cow in every four treated with a sequence of two injections of pregnant mare serum (PMS) have responded with a multiple birth.

It was recognized at the outset that the hormonal induction of multiple births would be accompanied by a number of problems of varying severity. Several of these problems have been the subject of previous reports, and this paper is another in this series.

Research conducted over 30 years ago with both laboratory animals and large farm animals, including the cow, suggested that animals develop a

[1]Appreciation is extended to Dr. David Meyerhoeffer for technical assistance.

In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

refractoriness to PMS as a result of receiving a series of injections repeated over a short period of time. Animals thus made refractory would no longer respond to PMS by superovulation. However, generally such refractoriness developed only after several injections of a fairly large dose of PMS given over a short period of time. Although there was no research to support such, it was not believed that a cow might develop a refractoriness to treatments one year that would persist to affect the response to treatments a year later.

The response observed in certain cows during studies of the past two years have suggested that some degree of refractoriness has been established and does persist.

The purpose of this experiment was to compare the response to a sequence of two PMS injections in cows that had never previously been injected with PMS to those that had.

Materials and Methods

This experiment utilized 32 lactating Angus cows that were observed in heat between May 15 and June 20. The cows were maintained on native grass pastures at the Southwest Livestock and Forage Research Station, El Reno. Twenty-two of the cows had never been previously treated with PMS, and the remaining 10 cows had received a single injection of 2000 IU PMS the previous year.

Starting in mid-May, the herd was checked twice daily for the occurrence of heat. Heat detection was aided by the use of vasectomized bulls wearing chin ball markers. As the cows that had not previously been injected with PMS were detected in heat, they were alternately assigned to either Treatment I or II. All cows that had been previously treated with PMS were assigned to Treatment III.

The three treatments used in this experiment were: Treatment I - no previous PMS - saline injections on day 5 and day 17 of the cycle designating day of heat as 0; Treatment II - no previous PMS - 1500 IU PMS on day 5 plus 2000 IU PMS on day 17; Treatment III - previous PMS - 1500 IU PMS on day 5 and 2000 IU PMS on day 17. All injections were made subcutaneously in the shoulder region. The cows were checked for the occurrence of heat following the PMS injections on day 5, but estrus was not observed. Following the day-17 injection, all cows were fitted with a K-Mar heat detector patch and placed in a lot with a fertile bull equipped with a chin ball marker to aid in detection of heat following treatment.

The PMS used in this study was a lipolyzed product that had been obtained in bulk from Argentina in 1973 and standardized to a potency of 200 IU/mg. It had been stored continuously in a freezer at -10°C. Just prior to use, it was assayed for potency in 21 day female rats against the World Health Organization Standard PMS preparation. For purposes of injection, the PMS was dissolved in sterile saline so five ml would contain the quantity required per injection.

Ovulation rates were determined in Treatments II and III by means of a high lumbar laparotomy performed seven to fourteen days after breeding. The ovulation rates of the cows in Treatment I were determined by means of rectal palpations carried out seven to 14 days after breeding. Blood samples were collected at several times during the study, and the plasma stored in a freezer for later analysis of estradiol and progesterone.

Results and Discussion

The response of the cows to the sequence of two PMS injections is presented in Table 1. There were too few cows in each group for any of the differences observed in ovarian response to be statistically significant. Therefore, the results being reported must be considered as trends that may or may not represent real differences between the treatments. Ovarian hormone production after PMS will be evaluated in these cows to determine whether treatment with PMS the previous year influenced estradiol production by the follicles and progesterone production by the corpora lutea.

Fewer cows were observed in heat following the PMS injection on day 17 than were observed in heat following saline injection. This could be a reflection of poor heat detection, but this seems doubtful since heat was detected in nine of the 11 cows of Treatment I. Previous treatment had no apparent effect on

Table 1. Reproductive performance of cows following a sequence of two PMS injections

	Treatment		
	I	II	III
	Saline treated	PMS treated	
Item	No previous PMS	No previous PMS	Previous PMS
No. Cows	11	11	10
No. observed in heat following second injection	9	5	5
Interval - last injection to heat (days)	5.4	5.4	7.2
Ovulation rate	0.9	5.5	2.3
Ovulation range	0 - 1	0 - 28	0 - 12
No. cows with			
0 ovulation	1	1	1
1 ovulation	10	3	7
2 ovulations	0	2	0
3 ovulations	0	1	0
4 ovulations	0	1	1
5+ ovulations	0	3	1

estrual response to PMS since five cows were observed in heat in each of the two PMS groups, (Treatments II and III). There was a suggestion that occurrence of heat, since cows of Treatment III that were observed in heat had a 1.8 day longer estrous cycle than did those of either Treatment I or II.

The superovulatory response of cows to PMS appeared to be influenced by PMS treatment the previous year. This is reflected in the differences in average ovulation rates for the cows in each PMS treatment group. The cows in Treatment II (not previously treated with PMS) averaged 5.5 ovulations compared to 2.3 ovulations per cow in Treatment III. The difference in response is very evident when the ovulatory response of individual cows is studied. Eight of the 10 cows that had been previously treated with PMS failed to superovulate and had only a single ovulation or no ovulation. This compares to four of 11 cows that had never been previously treated with PMS (Treatment II). Thus, there is the possibility that the PMS treatment in 1975 induced a refractoriness to future PMS injections that had a detrimental effect on the response of the cows to the injections given in 1976.

These results suggest the need for additional research with enough cows to determine the real effect of PMS injections repeated at yearly intervals. Certainly, if the trends observed in this study are real, this refractoriness must be taken into account in any practical use of hormone injections to induce multiple births in beef cow herds.

Maturation and Freezing of Bovine Oocytes

D. Mapes and M. E. Wells

Story in Brief

Immature bovine oocytes were aspirated from small to medium size follicles of bovine ovaries by needle and syringe. The ovaries were obtained from animals slaughtered in the Perkins or Oklahoma City slaughter houses. The oocytes were transported to the lab in a prewarmed thermos and used in *in vitro* studies to determine maturation and livability under various treatments. The oocytes were treated in three ways: (1) incubated in synthetic oviduct fluid (SOF) for 24 hrs, (2) frozen, thawed, then incubated in SOF for 24 hrs, or (3) incubated, frozen, thawed, then incubated again to test the effects of partial maturation. The maturation and freezability of these oocytes was checked by making chromosome spread preparations of the oocytes. These were examined, using both phase and standard light microscopes, for the stage of division. Incubation for 24-26 hours in SOF resulted in 92 percent of the oocytes maturing to the metaphase II stage. Attempts to freeze resting or partially matured oocytes are in progress.

Introduction

In vitro work has been done with oocytes and embryos in the areas of maturation, and maturation and long term storage, respectively. Maturation of immature bovine oocytes, aspirated from follicles has been quite successful (i.e., 80 percent or more of the oocytes completing maturation) when cultured in a modified SOF media. The maturation process takes the oocyte from the resting stage of prophase I to metaphase II of the meiotic division, at which time the egg is ready to be fertilized. Embryos, flushed from cows and incubated *in vitro*, have gone from the two-cell stage of development to the eight-cell or morula stage; from the eight-cell stage to the blastula stage; and from the 16-cell or morula to the expanded blastula stage. However, the percentage of embryos continuing development *in vitro* has been variable and generally not as high as oocyte maturation. Long term storage of embryos at -320°F has primarily been studied in small laboratory animals, such as the mouse and rabbit, and up to 70 percent of the stored embryos have resumed division post-freezing. One of the areas that has not been investigated is the livability of oocytes frozen at either the resting stage or some stage of maturity.

The objectives of this study were to characterize the effects of (1) incubation time on chromosomal development, and (2) various freezing procedures on viability of oocytes.

Experimental Procedure

Ovaries were removed from reproductive tracts of cows slaughtered at Oklahoma City or Perkins. Follicular contents were immediately aspirated from two to six mm follicles with a 12 ml syringe and an 18 gauge needle. The fluid containing the oocytes and surrounding cumulus cells was placed in test tubes or a thermos at 38°C for transport to the laboratory. Oocytes with several layers of cumulus cells were selected and rinsed in modified SOF.

For the maturation studies, 10 to 20 eggs were placed in 12 x 75 mm test tubes containing one ml of modified SOF media. The tubes were gassed with a mixture of gases containing 90 percent N_2, 5 percent O_2, and 5 percent CO_2, stoppered; and incubated in an oven at 38°C. Several eggs were removed every two to four hrs of the incubation period to determine the progression of the chromosomes through meiotic division to metaphase II.

Four different treatments were utilized to investigate the possibility of freezing unfertilized oocytes. In Treatments 1 and 2, oocytes were placed in 0.1 ml of culture media and placed in a water bath at 38°C. The cryoprotective agent, dimethylsulfoxide (DMSO), was added in two increments of 0.05 ml at 10 min. intervals resulting in a final concentration of 1.5 M DMSO. The tubes were transferred to an ice bath for 10 min, transferred to a seeding bath at -4.5°C, seeded, and then transferred to the cooling chamber. Treatment 1 tubes were cooled to -110°C at a rate of 0.33°C per min, and Treatment 2 tubes were cooled at a rate of 0.8°C per minute. Treatment 3 was the standard semen freezing technique, which was an 8 min freeze in liquid N_2 vapor to -180°C. In Treatment 4, the oocytes were incubated for 12 hr, as described for the maturation studies, then frozen at 0.8°C per min to -110°C. This approach was designed to test the effects of partially maturing the oocytes.

Oocytes frozen in Treatments 1, 2, and 3 were thawed after three to six days of storage, at a rate of 16°C per minute until they reached 0°C, and were then transferred to a 38°C water bath. The DMSO was diluted by addition of 0.2 ml, 0.2 ml, and 0.4 ml of culture media at two min intervals. Oocytes were then rinsed in culture media, transferred to culture tubes, and incubated at 38°C for 24 hrs.

Oocytes frozen in Treatment 4 were quick thawed in 35°C water, and then treated the same as described above for preparation for culturing.

Oocytes in Treatments 1, 2, and 3 were incubated for 24 hrs while those in Treatment 4 were incubated 12 hrs. Following incubation, follicular cells were removed from the oocytes by enzymatic digestion with hyaluronidase, treated with a hypotonic solution of 0.2 percent sodium citrate, fixed on slides with a

Table 1. Effects of incubation time on stage of division of bovine ooctyes

Hr of incubation	No. of oocytes	Percent of oocytes in				
		Prophase I		Metaphase I	Telophase I	Metaphase II
		Germ. ves.	Distinct. chrom.			
4	39	100	---	--	--	--
8	36	---	100	--	--	--
12	19	---	55	45	--	--
14	19	---	---	84	11	5
18	20	---	---	30	45	25
20-22	22	---	---	5	35	60
24-26	--	---	---	--	8	92

1:3 mixture of acetic and ethanol, and air dried. They were then fixed for at least 1 hr in the same fixative, and stained with Giemsa stain to visualize the stage of chromosome division.

Results and Discussion

The process of oocytes maturation begins with germinal vesicle, the resting stage of the immature oocyte, breakdown and the appearance of distinct chromosomes finishing prophase I of the meiotic division. The chromosomal division proceeds through metaphase I where they resemble cross-type structures, anaphase, and telophase. Then, after a short prophase, they go to the final maturation phase, metaphase II, where the divisional activity waits until fertilization occurs. Table 1 presents the summary of the several studies conducted to develop procedures, and characterize the effects of incubation time on oocyte maturation. These data show that germinal vesicle breakdown and appearance of distinct chromosomes occurred between four and eight hours after initiation of culturing. At 14 hours, 85 percent of the oocytes were at the metaphase I stage. Between 18 to 22 hrs of culture are necessary for the oocytes to reach the maximum percentage progressing to the telophase stage. It took 24-26 hr of culture for the maximum percentage of the oocytes to progress to the metaphase II stage. Table 1 presents the data on only those oocytes where the divisional stage was identifiable. The number of cultured oocytes not showing an identifiable stage was usually less than 5 percent. Therefore, we conclude that 85-90 percent of the immature oocytes secured from excised ovaries and matured *in vitro* will progress through meiotic division as they would in the intact cow. Such consistent techniques will prove to be quite valuable in studies on oocyte properties and utilization.

Table 2 presents a summary of the attempts to freeze oocytes. The freezing rates in Treatments 1, 2 or 3 did not yield viable oocytes post-thaw. This is likely due to the fact that the oocyte, and the surrounding follicle cells are greatly different in size and have differing optimum freezing rates. One or the other is likely killed in freezing. Reports have shown that the follicle cells supply nutrients to the oocyte as it matures, and disruption of these cells by freezing may be the reason frozen oocytes do not mature. Treatment 4 was an

Table 2. Summary of effects of freezing on oocytes

Treatment	No. of oocytes	No. maturing
1 (.33°C/min)	270	0
2 (.8°C/min)	96	0
3 (8 min to -180°C)	122	0
4 (12 hr incub + .8°C/min)	75	0

attempt to get around this problem with the theory that partially matured cells may be better able to withstand freezing. Although the first study (Table 2) indicates no cells resuming maturation, later studies have yielded low percentages of viable cells after partial maturation, freezing, and completion of the required incubation period. Studies are continuing on ways to increase the manipulation and utilization of oocyte populations.

Summary Reports

Meat and Carcass Evaluation

The Association Between Net K^{40} Count and Carcass Composition of Gestating Gilts

D.D. Johnson, L.E. Walters, C.V. Maxwell and B.W. Lambert

Previous work at the Oklahoma Agricultural Experiment Station has shown a significant increase in nitrogen storage in bred gilts when fed high protein diets. Other work in swine nutrition suggests that a part of the increased nitrogen storage may be in increased muscle growth. Information leading to storage sites for this nitrogen (in addition to embryonic storage) would be of considerable benefit to swine nutritionists in efforts to more thoroughly describe the nature of bred gilt nutrition.

Inasmuch as the K^{40} whole-body counter has proven to be an effective instrument for predicting fat-free lean in 220 to 240 pound market hogs, the question of its application in monitoring muscle growth in gestating gilts has arisen. In an effort to study the application of the K^{40} whole-body counting technique to muscle deposition during gestation, twenty-two gilts with an average weight of 283 pounds were K^{40} counted and subsequently bred. Following breeding, the gilts were placed on rations containing three different levels of protein and two levels of energy. The gilts were then K^{40} counted on days 30, 60, and 90 of gestation. At the same time, backfat thickness was estimated by an ultra sound probing technique (Scanogram). All animals were slaughtered at the 90th day of gestation, at which time weights of the placenta (with fetus) and the amount of amnionic fluid was measured. After chilling for 48 hours, each right carcass half was cut into the standard wholesale cuts. Each of these cuts was then separated into very closely trimmed lean, fat, and bone. Table 1 presents means of the data collected to this

Table 1. Means of certain live and carcass measurements

Gilt wt. (lbs.)	Carcass wt. (lbs.)	Days of gestation	Net K^{40} count	Backfat probe (in.)	Lbs. of cl. tr. lean	Lbs. of fat trim
312		30	5546	.88		
357		60	5677	.96		
385	238.9	90	6098	1.06	138.26	73.90

point for gilt weight, net K^{40} count, carcass weight, pounds of closely trimmed lean, backfat probe, and fat trim. The simple correlation between mean net K^{40} count and pounds of very closely trimmed lean was found to be 0.85, which sugggests a positive relationship between the last K^{40} count and the actual pounds of muscle in the animal. Greater numbers of animals must be studied before meaningful prediction equations can be developed. When total pounds of fat trim were compared to the Scanogram fat measurement, the data also suggested a positive relationship, from twenty-eight observations, of 0.75 between these two measurements.

In an effort to more accurately identify muscle development in gestating gilts, the effect of weight on the counting efficiency of the K^{40} counter must be determined. It has been demonstrated previously at this station that in beef cattle as weight or mass increases, the efficiency of the K^{40} counter decreases. Other workers in this area have demonstrated that "background depression" and "self-absorption" of the naturally occuring K^{40} is primarily responsible for this loss in counting efficiency. A study is now underway in an effort to identify this loss in counting efficiency in phantoms of weights similar to those of bred gilts between the weights of 240 and 440 pounds. Upon completion of data collection and statistical analyses, a more detailed report of the findings will be presented.

The Estimation of Muscle Cell Numbers in Cattle

J. J. Guenther and R. V. Felber

This research was initiated to develop methods for estimating muscle cell population in bovine muscle. The semitendinosus, biceps brachii, sartorius, and tricepts brachii muscles from a fifteen-day-old Jersey and a fifteen-day-old Holstein calf were removed immediately post-mortem. These muscles were selected for initial investigation because the fibers from these muscles run in one direction, facilitating the obtaining of true cross-sections. The number of muscle cells was estimated, using a microscopic procedure, in cross-sectional areas at 25, 50, and 75 percent of the muscle length. Average cell number for the above named muscles from the Jersey calf were 92.5, 28.4, 34.1 and 47.5 X 10^4, respectively. Cell counts for the Holstein calf were significantly higher, averaging 114.8, 42.2, 48.8 and 59.7 X 10^4, respectively. A strong positive relationship between cell number and muscle weight was indicated by the results.

Muscle Nitrogen Deposition During Growth in Cattle Differing in Body Size

J.J. Guenther

The current profit squeeze has caused beef producers to become more acutely aware of the importance of maximizing production efficiency, with their ultimate goal being to produce quality lean tissue or muscle at the least possible cost. As a result, much interest has been generated in comparing the muscling capabilities of various newer or "exotic" breeds of cattle with those of the standard British breeds in use in the U.S.

The principal constituent of muscle, except for water, is protein. Muscle protein may be separated into its major components: myofibrillar protein, which gives structure to the muscle; sarcoplasmic protein, which contains various enzymes and pigments; and stroma proteins, which comprises the connective tissue of muscle. Each of these components may be conveniently quantitated on the basis of its individual nitrogen content.

This study was conducted to obtain information on the influence of body size in beef muscle nitrogen deposition from early life to a constant market age.

Muscle samples were obtained, via live-animal biopsy, from the longissimus dorsi muscles of eight Angus and eight Charolais crossbred steer calves, beginning when the calves were about one month of age, and subsequently at two month intervals until the calves were about 15 months of age. The Angus calves were selected to represent the small scale body type and were not intended to be representative of the Angus breed. The Charolais calves were selected to represent the large scale body type. Protein nitrogen was extracted, and partitioned into the appropriate fractions following procedures developed in our laboratory.

Results from the muscle nitrogen analyses are presented in Figure 1. The data are presented on a percent of wet tissue basis rather than on an absolute basis in order to show a more direct comparison between the two breed types. Percent total protein nitrogen increased during growth ($P<0.01$) in both breed types, and this component was greater ($P<0.05$) for the large scale (Charolais) cattle. The rate of deposition of total muscle protein nitrogen proceeded at its maximum between the five and eleven-month test periods for the Charolais steers. In general, the small scale (Angus) cattle showed trends similar to those of the large scale cattle in total muscle protein nitrogen deposition. However, the Angus calves appeared to attain maximal rate of increase in this component about sixty days earlier than the Charolais.

Myofibrillar protein nitrogen deposition increased during growth ($P<0.05$) in both breed types, but there were no significant differences be-

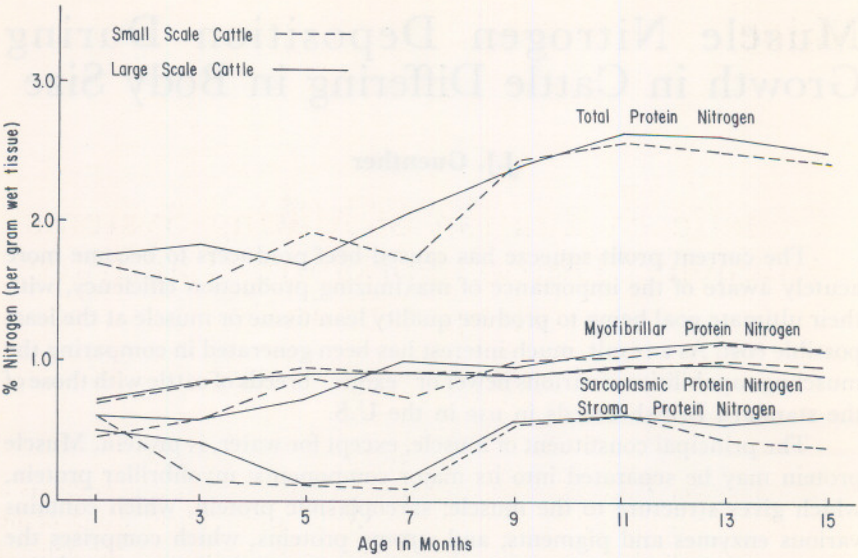

Figure 1. Changes in percent muscle nitrogen during growth in cattle of different body size.

tween breed types. Sarcoplasmic protein nitrogen exhibited only slight increases during growth, and was about the same for both types of cattle. Stroma protein nitrogen decreased during early life, but increased post-weaning ($P<0.01$), and was higher ($P<0.05$) for the Charolais calves.

Genetic Evaluation of Mating Systems Involving Duroc, Yorkshire, Landrace and Spot Swine

R.K. Johnson

Commercial swine producers recognize the value of crossbreeding as a very high percentage of the pigs produced are of crossbred origin. Much of the swine crossbreeding research has been done at Oklahoma, and the general response from crossbreeding is known. Of all traits evaluated, reproductive performance has shown the greatest response. Crossbred sows farrow and wean larger litters than purebred sows, and crossbred pigs grow faster and more efficiently than purebreds.

However, there is little information available on the performance of some potentially productive breeds. Also, male reproductive efficiency has not been sufficiently evaluated to identify mating systems that maximize total production efficiency. Are specific combinations of three or four breeds more efficient than rotation crosses? How important is the boar to reproductive efficiency? Can total efficiency be improved with the use of crossbred boars and crossbred sows?

In an effort to answer these questions, Project 1620 was initiated to evaluate the purebred performance, and the combining ability of Duroc, Yorkshire, Spot, and Landrace in two-breed, three-breed, and four-breed crosses.

Four purebred herds were establihed at the Experimental Swine Farm at Stillwater. In the first phase, purebred boars and gilts are mated in all combinations to produce purebred and two-breed cross pigs. The first pig crop was produced in the fall of 1977 and consisted of 19 litters from purebred Duroc females, 20 from purebred Yorkshire females, and 18 from each of purebred Spot and Landrace females. Crossbred gilts from these litters will be mated to purebred and crossbred boars to evaluate three and four-breed cross systems. Thirty boars and 180 gilts will be mated at the Southwest Livestock and Forage Research Station. All breeding stock for this phase will come from

In cooperation with U.S.D.A., Agricultural Research Service, Southern Region.

the Stillwater foundation herds. Differences in conception rate and litter size between purebred and crossbred boars and between various combinations of crossbred gilts will be evaluated. In addition, boars will be castrated to evaluate testicular and sexual development.

Several replications of each phase will be completed. New boars are constantly being introduced into the foundation herds at Stillwater to maintain a broad genetic base for each breed.

Feedlot

Fermentation of Ground High Moisture Corn Treated With Aqueous Ammonia

J.H. Thornton, F.N. Owens and M. Arnold

Treating corn silage at ensiling time with aqueous ammonia, or anhydrous ammonia by use of a cold chamber, is reported to produce a high quality product containing more nitrogen, less solubilized corn plant protein, and greater quantities of organic acids than untreated corn silage. Whether treating ground high moisture corn grain before ensiling would induce similar changes was uncertain. This preliminary study was initiated to determine if favorable alterations in fermentation could be induced by ammonia addition and, if so, what level of ammonia would be needed.

Aqueous ammonia was applied to ground high moisture (27 percent moisture) corn grain to supply 0.0, 0.1, 0.15, 0.2, 0.3, 0.4, 0.6, 0.8 and 1.2 percent ammonia. After thorough mixing, material was packed in eight replicate lab silos (quart glass jars), sealed, and allowed to ferment for 7, 14, 28 or 56 days. Upon opening, pH, lactate, ammonia nitrogen (N), total N, soluble N, and soluble non-protein N were determined.

Untreated material had the lowest pH (Figure 1) in each time period, and pH declined through 28 days at all treatment levels. Lactate (Figure 2) generally increased with time ensiled. Ammonia additions from 0.1 through 0.4 percent increased lactate levels over the control (0 ammonia), with peak lactate levels appearing at 0.3 or 0.4 percent ammonia. Higher ammonia levels, 0.6 through 1.2 percent, inhibited fermentation. Soluble nitrogen (Figure 3) increased with time, and ammonia additions slightly reduced solubilization of corn protein.

This preliminary study indicates that low levels of ammonia, below 0.4 percent, will stimulate fermentation and increase lactate production. With levels of 0.3 percent ammonia or less, resulting pH was low enough for good preservation, and no noticeable ammonia odor was present. Higher levels of ammonia, 0.6 percent and above, inhibited fermentation. Such material may not preserve for extended time periods and may have objectionable odors due to residual ammonia.

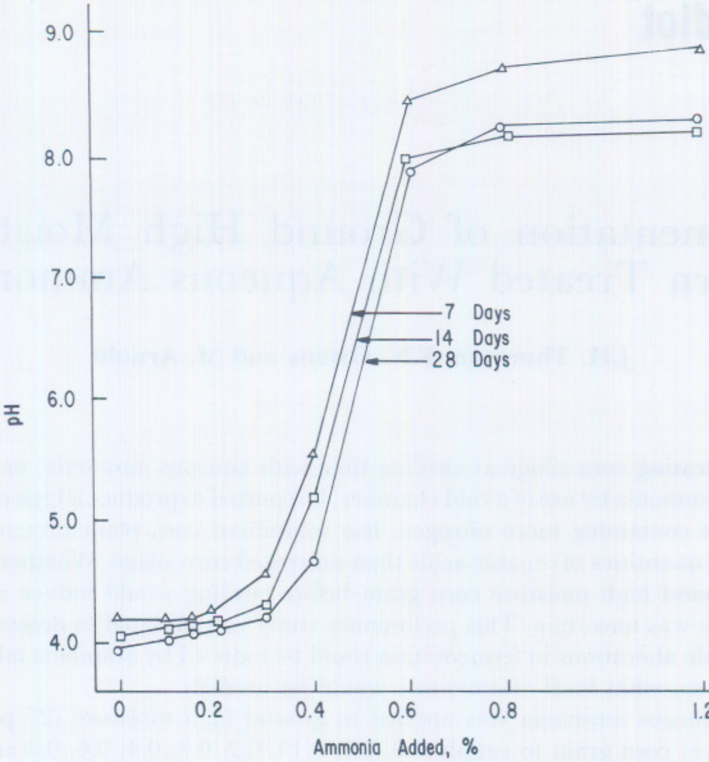

Figure 1. Effect of ammonia additions and time after ensiling on pH of ensiled ground high moisture corn grain.

Based on this preliminary study, a larger quantity of ground high moisture corn grain was treated with 0.3 percent ammonia and a feeding trial with this material is currently underway.

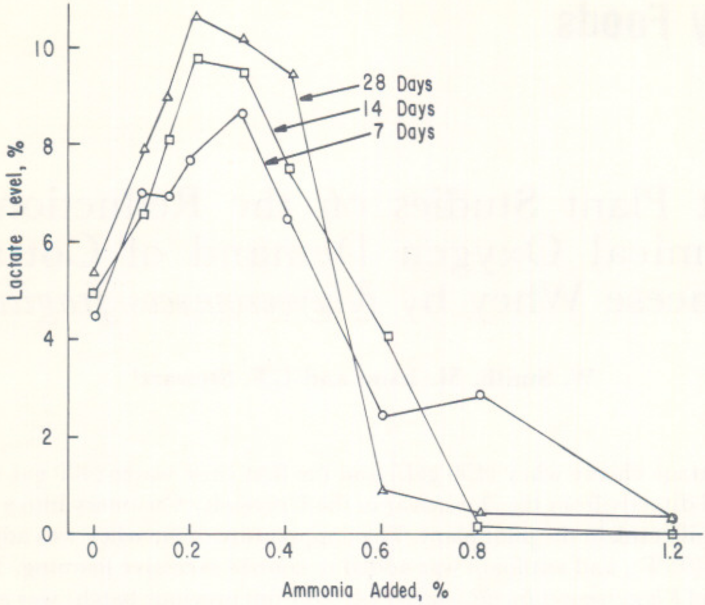

Figure 2. Effect of ammonia additions and time after ensiling on lactate of ensiled ground high moisture corn

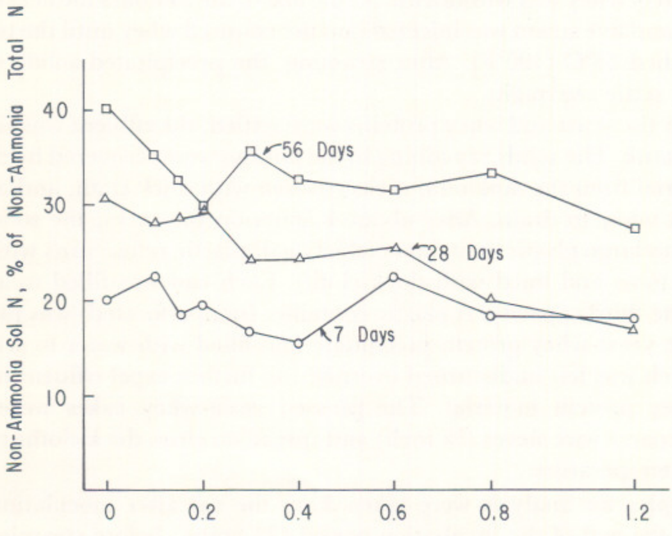

Figure 3. Effect of ammonia addition and time after ensiling on non-ammonia soluble nitrogen

Pilot Plant Studies on the Reduction of Chemical Oxygen Demand of Cottage Cheese Whey by *Kluyveromyces fragilis*

W. Smith, M. Lane and C.F. Stewart[1]

Cottage cheese whey (450 gal.) and the first rinse water (400 gal.) were pumped directly from the cheese vat in the University Creamery into a 1,000 gallon milk tank in the pilot plant. The temperature of the whey was adjusted to 35°C (95°F), and antifoam was added to control excessive foaming. Thirty gallons of *Kluyveromyces fragilis* starter (saved from previous batch) was added, and the mixture was allowed to incubate 24 hours with continuous aeration. The system was aerated by sparging air through a perforated stainless steel pipe in the bottom of the tank. At the end of 16 hours, sufficient starter for the next batch of whey was withdrawn. At the end of the 24 hours the aeration was stopped, and live steam was injected into the cultured whey until the temperature reached 88°C (190°F). After steaming, the precipitated solids were allowed to settle overnight.

After the yeast and whey proteins were settled, the effluent was siphoned from the tank. The solids remaining in the bottom were recovered by draining the material from the tank onto racks covered with duck cloth, and allowing the spent whey to drain. After about 4 hours on the racks, the solids were placed into large plastic containers (thirty gal. plastic refuse cans with perforated bottoms and lined with duck cloth). Each can was filled to approximately one third capacity. A plastic container (nonperforated) was placed on top of the yeast-whey protein precipitate and filled with water to serve as a press. Each was left undisturbed overnight to further expel effluent from the yeast-whey protein material. The pressed yeast-whey cakes were forced through coarse wire sieves (¼ inch) and spread on clean duck cloths to dry at ambient temperature.

Samples for analysis were taken from the vat after inoculation ("O" time), at the end of the incubation period (24 hours) before steaming, after steaming when the solids had settled (effluent), after draining (yeast-whey

[1]Agricultural Marketing Research Institute, ARS, Beltsville, Md.

Table 1. Analyses of samples from cottage cheese whey cultured with *K. fragilis*

	Lactose %	Protein %	BOD's mg/1	COD mg/1	pH
"O" time	2.15	0.46	24,172	50,120	4.7
24 hours	0	0.36			5.0
Effluent		0.14	12,943	25,457	5.1
Yeast-whey paste		10.13			
Dried yeast-whey		73.75			

paste), and after drying (dried yeast-whey). The results of these analyses are presented in Table 1.

K. fragilis completely utilized the lactose in the cottage cheese whey and reduced the BOD's and COD of the whey 46 percent and 49 percent, respectively. The yeast-whey protein material obtained can be used in formulating human or animal foods. The dried material contained 73.75 percent protein.

The Continuing Study of Wheat Pasture Flavor in Milk

R.L. Von Gunten, L.J. Bush, M.E. Wells, E.L. Smith and G.D. Adams

The lush green wheat pastures available to the dairyman each fall and spring are a lure to trouble. The cows consume it readily and as a result the milk produced has a highly undesirable taste and odor. This odor is "fishy" in nature and has been analyzed to be trimethylamine. Earlier work from this station confirmed that the amount of wheat consumed was directly related to the amount of fishy flavor in the milk.

Current work is being undertaken to determine if there is a high grain yielding variety of wheat that can be grazed with less off flavor being generated in the milk. Tam-101, Osage, and Triumph-64 varieties have been investigated with only slight variation observed in the off flavor produced after grazing. There was not enough variance to influence the grain selection by the dairy farmer.

It would appear that herd management to control the extent and time of grazing is the best tool currently available to limit the production of trimethylamine.

Poultry Physiology

Endocrine Function in Laying Hens as Related to Egg Shell Quality

J.S. Curl and R.H. Thayer

One of the highest priority problems in the commercial egg industry in the United States today is a deterioration in egg shell quality which takes place as the egg laying period progresses. Under commercial production conditions the egg shell quality problem routinely develops in the following way. Egg shell quality appears to be good during the initial four to six months of the laying period. Beginning at this time and extending through the remainder of the egg production period, there is a significant progressive deterioration in egg shell quality which is characterized by a decrease in shell thickness, shell texture, and shell strength. This decrease in egg shell quality develops in about 25 percent of the layers in any given flock. While the eggs are being processed and moved in market channels, a large number of these thin shelled eggs may become cracked, checked, or broken. As a result, the economic loss to the producer is substantial. Counter measures of many kinds have been taken to correct the problem, but none have been entirely effective.

One of the most promising areas for study on this problem involves endocrine function as it is related to calcium and phosphorus intake, mobilization, and deposition in the egg shell. No data are available to indicate what fluxuations, if any, occur in the blood plasma concentrations of the different hormones under practical production conditions during an extended egg production period. In addition, it is not known whether changes in plasma hormone levels, if they do occur during this time, are related to the determination of egg shell quality.

A strain of commercial hybrid hens, which is known to develop the egg shell quality problem, has been divided into groups according to degree of shell thickness, shell texture, and shell strength by measuring egg specific gravity. Clutch size, time sequence of ovulation, and time sequence of oviposition for hens with both good and poor shell quality have been established. Blood samples have been taken by heart puncture from hens within each shell quality classification six hours prior to ovulation. These blood samples are to be analyzed by radioimmunoassay for estradiol, testosterone, and progesterone. Data obtained on plasma concentrations of these hormones will be used to determine if any correlation exists between possible differences in plasma hormone levels and egg shell quality. If correlations do exist, further studies involving these and other hormones will be undertaken.

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On campus, the cooperation of staff in the College of Veterinary Medicine, and the Departments of Biochemistry, Agronomy, Agricultural Economics, Agricultural Engineering, Microbiology, and Entomology was important in the design and implementation of several projects.

Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with U.S.D.A., Agricultural Research Service, Southern Region, Texas-Oklahoma Area. The assistance and counsel of Dr. M. B. Gould, present Superintendent of the Station, is gratefully acknowledged. Several studies at Stillwater were part of regional research projects.

The following is a listing of those who have contributed to research programs of the Animal Science Department during the preceding year.

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