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Comparison of Productivity of Young Angus-Holstein Crossbred and Grade Angus Cows

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Story in Brief

The productivity of 69 young ½ Angus-½ Holstein crossbred cows was compared to that of 41 young grade Angus cows of the same age. All were mated to yearling Angus bulls for spring calving, first as 2-year-olds. The cows were managed under range conditions on native grass the year around. During the winter they were supplemented with prairie hay and cottonseed meal cubes. Traits evaluated were calving percent, milk production, calf weights and cow weight changes. Milk production was estimated by the calf nursing method. Calves were weaned at an average age of 205 days. Cow weights and condition scores were taken three times a year.

The crossbreds in comparison to the Angus cows had a +3, —26 and +13 calving percentage difference as 2, 3 and 4-year-olds, respectively. The Angus dams lost on the average 10 percent more calves each year. This resulted in a percent calf weaned difference of +11 and —35 when comparing the crossbred to Angus dams as 2 and 3-year-olds, respectively. The average calving dates were 5, 11 and 13 days earlier, respectively, for the 2, 3 and 4-year-old crossbred dams. The birth weight of calves of the 2 and 3-year-old crossbred cows was 12.7 and 9.1 pounds more for bull and heifer calves, respectively, than contemporary straightbred calves; but the difference was nonsignificant for 4-year-old dams.

For an adjusted 200 day lactation, the average daily milk production was 8.8 and 12.6 pounds for the 2-year-old and 11.5 and 13.9 pounds for the 3-year-old Angus and crossbred cows, respectively. The average adjusted weaning weight advantage of the backcross calves was 53 and 76

pounds for steers and 69 and 78 pounds for heifers from the 2 and 3-year-old dams, respectively. No significant difference was found within sex between the two calf breed groups in condition or conformation grade at weaning. The crossbred cows were larger in size and carried less condition during their first and second lactations. Both cow breed groups lost weight during their first lactation but gained during their second lactation. The Angus cows lost less weight during the first lactation and gained more during the second lactation.

Three-year-old cows of both breed groups produced more milk, weaned heavier calves, rebred at a higher rate and lost less body weight during lactation than did 2-year-old cows of the same breed. It appeared from this study that the ½ Angus-½ Holstein cows were capable of producing more milk and heavier weaning calves than the Angus cows as both 2 and 3-year-olds; but the crossbreds apparently needed a higher nutritional level, especially as 2-year-olds, to rebreed and continue to grow.

Introduction

The constant need of beef producers to utilize new ways to increase calf weaning weights has stimulated extensive research. With the advent of the exotic breeds increased research emphasis is being placed on crossbreeding programs and on the performance of the crossbred individual. This expansion in beef research has stimulated interest in dairy-beef crossbreeding as a means of rapidly increasing milk production in the beef cow, since selection progress for this trait is slow. A report from this station in the 1970 Misc. Publ. No. 84 by Deutscher *et al*, summarized a study comparing the performance of 2-year-old Holstein-Angus crossbreds and grade Angus heifers. This study was continued until three years reproductive performance data was obtained on these cows. Another group of 2-year-old Angus-Holstein crossbreds was also included in this continued study. This report will summarize the productivity of the young crossbred and Angus cows.

Materials and Methods

In early 1968, 39 ½ Angus-½ Holstein crossbred and 41 grade Angus heifer calves were assembled at the Lake Carl Blackwell range west of Stillwater. In late 1968, 30 more ½ Angus-½Holstein crossbred heifer calves were added to the herd.

This study was superimposed on the progeny test breeding project at the Blackwell range; thus, these cows were managed as part of that project. Each year each female was randomly allotted within breed and age to a 25 to 30 cow breeding group and exposed to a yearling registered

Angus bull from May 1 to August 1. The first group of 39 crossbred and 41 straightbred heifers was bred as yearlings in 1968, and the second group of 30 crossbreds was bred as yearlings in 1969.

The heifers and cows were managed under range conditions with only native grass during each grazing season. A salt and bonemeal mixture was available free choice. The winter supplemental feed during 1968-69 consisted of 2 pounds of cottonseed meal cubes and 5 pounds of prairie hay per head daily. The cubes were fed from the middle of November to the middle of April, and hay was fed from January 1 to April 15. The same general feeding regime was used during the winter of 1969-70 except that the cubes were increased to 3 pounds per head per day, and all the hay they desired was given from the last part of February until the last of April. This feeding regime was used again in the winter of 1970-71 except that the crossbred cows received from 2 to 4 pounds of cubes per head daily depending upon the cows' condition.

The calving season began each year about February 1. The calves were weighed, tatooed and ear tagged within 24 hours after birth; and calving losses were recorded. Milk production was estimated by the calf nursing method which involved weighing the calves before and immediately after nursing with the difference in weight being used as an estimate of the amount of milk consumed. This procedure was used 2 or 3 times daily, depending on the age of the calves, to estimate the cows' daily milk production. The first estimate was made when a calf was about 2 weeks old and at two week intervals thereafter until the first of May; after which time, a randomly selected group from each breed was tested every four weeks until weaning. To calculate total milk yield, each estimate was used as the average daily yield for the time period in which it was centered.

The calves were weaned, weighed and given conformation and condition scores in late September. All weaning weights were adjusted to 205 days of age. Conformation scores were given from a one to 17 scale with 17 being the top prime grade. Rebreeding performance of the cows was evaluated from a pregnancy check in October and the calving data obtained the next spring. Cow weights and condition scores were taken each year before calving, before breeding and after weaning. The condition scores were based on a scale of one to nine with one being very thin and nine being very fat.

The study reported in this paper ended with the birth data obtained in the spring of 1971. Thus, the data reported for 4-year-old dams is only from the first group of cows assembled in early 1968 as is the weaning data for 3-year-old dams.

Results and Discussion

Breeding and Calving

A summary of the breeding and calving results is given in Table 1. Eighty-six percent of the crossbred and 83 percent of the Angus heifers calved as 2-year-olds. The crossbred heifers lost 9 percent fewer calves and appeared to have less calving difficulty as 2-year-olds. The larger calving percent and smaller percent calves lost resulted in the 2-year-old crossbred heifers having an 11 percent advantage in calves weaned. The crossbreds as 2-year-olds averaged calving five days earlier (March 1) than the Angus heifers (March 6); however, the range in dates was quite large for both groups.

The calving performance of the two groups as 3-year-old cows was quite discouraging and much lower than their 2-year-old performance as seen in Table 1. Only 49 and 75 percent of the crossbreds and Angus respectively, calved as 3-year-olds. The 37 percent drop in calving percent for the crossbreds was quite large compared to the 8 percent drop of the Angus cows. Thus, there was a 26 percent advantage ($P<.005$) in calving percent for the Angus cows as 3-year-olds; whereas, there was a 3 percent disadvantage for them as 2-year-olds. All cows (except two crossbreds) that were open as 3-year-olds had calves as 2-year-olds, and all heifers (except the same two crossbreds) that were open or had lost calves as 2-year-olds produced calves as 3-year-olds. Of those cows which raised a calf as a 2-year- old, 68 and 36 percent of the Angus and crossbred dams, respectively, raised a calf as a 3-year-old.

The mature cow calving performance of the Angus herd, of which these cows were a part, was normal for these years; and thus, these low reproduction levels are probably not just the results of a bad year. The crossbreds showed the greatest reproduction decline. This was probably because of their higher milk production level (Table 2), slower weight gain and poorer condition during the breeding season (Table 5). These data support the idea that beef females of these two types under normal range conditions need a higher plane of nutrition than given in order to support lactation and desired growth and to rebreed consistently as 2-year-olds.

The Angus cows continued as 3-year-olds to lose a larger percent of their calves (Table 1) than the crossbred cows (10 vs. 0 percent); but the Angus cows still had a 35 percent higher weaning rate. As seen in Table 1 the 3-year-old crossbreds continued to calve earlier (11 days) ; also, the range in calving dates for both breed groups was longer as 3 than as 2-year-olds.

As 4-year-olds the crossbreds reversed the trend and exceeded the Angus dams in calves born by 13 percent (Table 1). Both breed groups

Table 1. Breeding and Calving Results of the Angus-Holstein (AXH) Crossbred and Grade Angus Cows

Age (Yrs.)	Breed	Exposed Number	Full-term Calving Percentage of Exposed	Calves Lost Percent	Calves Weaned Percentage of Exposed	Calving Date: Range (Day of Year)	Calving Date: Average
2	Angus	41	82.9[7]	20.6	65.9	31-118	Mar. 6
	AXH	69	85.5[7]	11.3	76.8	35-118	Mar. 1
3	Angus	40[1]	75.0[7]	10.0	67.5	31-130	Mar. 15
	AXH	69	49.3[8]	0.0[5]	32.5[5]	32-118	Mar. 4
4	Angus	39[2,3]	82.1[7]	---[6]	---[6]	40-116	Mar. 6
	AXH	39[4]	94.9[7]	---[6]	---[6]	37-79	Feb. 21

[1] One Angus heifer died as a two-year-old during parturition.
[2] One Angus cow died as a three-year-old of unknown cause.
[3] Five Angus included-pregnancy tested open and culled in fall.
[4] One AXH culled-open two years in a row.
[5] Based on only 40 cows exposed.
[6] Study terminated prior to collection of data.
[7,8] Percentages with different superscripts within column within age of cow are significantly ($P<.005$) different.

Table 2. Milk Production Adjusted for Lactation Length and Yield Per Day at Early, Late and Entire Lactation for the 2 and 3-year-old Cows by Breed

Dam: Age (Yrs.)	Dam: Breed	Calving to May 1: No.	Calving to May 1: Ave. Adj. 60 Day Yield (lbs.)	Calving to May 1: Ave. Yield Per Day (lbs.)	May 1 to Weaning: No.	May 1 to Weaning: Ave. Adj. 140 Day Yield (lbs.)	May 1 to Weaning: Ave. Yield Per Day (lbs.)	Entire Lactation: No.	Entire Lactation: Ave. Adj. 200 Day Yield (lbs.)	Entire Lactation: Ave. Yield Per Day (lbs.)
2	Angus	26	585.0	9.75	13	1191.4	8.51	13	1750.0	8.75
	AXH[1]	38	784.8	13.08	23	1683.3	12.02	21	2510.0	12.55
	Diff.		199.8**	3.33**		491.9**	3.51**		760.0**	3.80**
3	Angus	9	674.4	11.24	12	1558.2	11.13	6	2294.0	11.47
	AXH[1]	11	906.6	15.11	10	1939.0	13.85	9	2776.0	13.88
	Diff.		232.2**	3.87**		380.8*	2.72*		482.0*	2.41*

[1] ½ Angus-½ Holstein
* ($P<.05$)
** ($P<.01$)

performed at a much higher and more acceptable reproductive rate as 4 than as 3-year-olds. Many of the cows of both breed groups, especially crossbred, did not nurse a calf as a 3-year-old; thus, they had a rest period from the normal reproductive cycle which tended to allow them to grow, mature and recover from what was probably a previous nutritional inadequacy. Also, the winter nutrition level was increased on all cows as 3-year-olds which probably improved their 4-year-old calving performance. The possible effect of the one year rest period was pointed out by the fact that all cows not having a calf as a 3-year-old did have one as a 4-year-old.

The crossbreds continued as 4-year-olds to calve earlier (13 days) on the average than the Angus dams (Table 1). Both breed groups as 4-year-olds had less variation in calving dates than as 3-year-olds, especially the crossbred cows.

Milk Production

The lactation period was divided at May 1 because milk estimates could not be obtained on all cows during the breeding season. Table 2 gives the milk production data of the cows by breed as 2 and 3-year-olds from calving to May 1, May 1 to weaning and for the entire lactation. As 2-year-olds, the crossbreds produced significantly ($P<.01$) more milk during both periods of lactation and for the entire lactation than the Angus. During early lactation, the crossbreds produced 200 pounds more milk in the adjusted 60 day period or 3.3 pounds more per day. The production of the crossbreds during the summer was 492 pounds more or about 3.5 pounds more per day. The adjusted 200 day lactation of the 2-year-old crossbreds was 2510 pounds compared to 1750 pounds for the Angus. This gave the crossbreds a milk production advantage of 760 total pounds or 3.8 pounds per day.

The milk production of the crossbreds as 3-year-olds was significantly ($P<.05$) higher than that of the Angus during both periods and for the entire lactation. The crossbreds produced 232 pounds more milk for the adjusted 60 day early lactation. During the summer, the crossbreds produced 381 pounds more milk. The adjusted 200 day lactation of the 3-year-old crossbreds was 2776 pounds compared to 2294 pounds for the Angus. This difference of 482 pounds represents 2.4 pounds per day more for the crossbreds.

In comparing the 2 vs. 3-year-old crossbreds the 3-year-olds produced about 2 pounds more milk per day during early lactation and 1.8 pounds more per day during the summer. However, the difference for the entire lactation was not statistically significant. The comparison of the Angus 2 vs. 3-year-olds shows that the 3-year-olds produced 1.5 pounds more milk per day during early lactation and 2.6 pounds more per day during the summer. The 544 pounds advantage for the 3-year-olds for the entire lactation was statistically significant ($P<.01$).

Calf Performance

As shown in Table 3, the average calf birth weight of the backcross calves (¾ Angus-¼ Holstein) of both sexes at each age of dam was heavier than that of the contemporary Angus calves. However, the significant ($P<.01$) advantage of the backcross over the straighbred calves of 2 and 3-year old dams almost completely disappeared when the dams were 4-year-olds. Within both breed groups for each age of dam the bull calves weighed more at birth than their heifer contempories. The birth weight advantage of the backcross calves over the straightbreds appeared to give them an advantage from the start, especially calves of 2 and 3-year-old dams, which was seen thru to weaning (Table 4).

Complete data thru weaning was only available on calves of 2 and 3-year old dams. The summary of weaning weights and conformation and condition grades in Table 4 shows a significant ($P<.01$) weaning weight advantage for the backcross calves of both sexes at each age of dam. The backcross steers out of 2 and 3-year-old dams were 53 and 76 pounds heavier, respectively, than the Angus steers; and the backcross heifers out of 2 and 3-year-old dams were 69 and 78 pounds heavier, respectively, than the Angus heifers. Thus, the difference in weaning weights of the two calf breed groups was more for 3 than for 2-year-old dams. The

Table 3. Birth Weights of Calves from Angus-Holstein (AXH) Crossbred and Grade Angus Dams

Dam		Calf		Birth Weight	
Age (Yrs.)	Breed	Sex	No.	Ave. (lbs.)	SE[3]
2	Angus	Bull	14	52.9[1]	1.70
	AXH		27	65.7[2]	1.77
	Angus	Heifer	19	51.5[1]	1.46
	AXH		26	59.9[2]	1.81
3[4]	Angus	Bull	17	61.8[1]	1.54
	AXH		13	74.4[2]	2.56
	Angus	Heifer	13	56.5[1]	1.76
	AXH		21	66.3[2]	2.01
4[4]	Angus	Bull	19	78.0[1]	1.46
	AXH		20	81.3[1]	2.76
	Angus	Heifer	13	72.5[1]	1.76
	AXH		17	72.8[1]	2.24

[1,2] Means with different superscripts within column within age of dam within calf sex are significantly ($P<.01$) different.
[3] Standard Error.
[4] No statistically significant difference in birth weight was found due to previous reproductive performance of cows in either breed group. Thus, all calves of each breed-sex group represented in these means.

backcross calves were heavier at weaning than the straightbreds probably due to more available milk, larger birth weights and heterosis for gain. The 13 and 9 pound advantages, respectively, of the backcross male and female calves at birth was increased on the average to 65 and 74 pound advantages over their straightbred contemporaries at weaning. The backcross calves gained approximately 0.3 pounds per day faster than the Angus calves from birth to weaning.

The weaning conformation and condition grades were all near low choice (grade 12). No difference between breed groups of calves within age of dam within sex was as large as 1/3 of a grade. This indicated that the 1/4 dairy blood did not appreciably affect the quality or beefy appearance of the backcross calves.

Cow Weight Change

Table 5 gives the means and standard errors of the weights and condition scores from before calving to after weaning of the 2 and 3-year-old cows that nursed calves. The 2-year-old crossbreds were significantly ($P<.01$) heavier in weight and lower in condition score than the Angus heifers before calving, before breeding, and after weaning. The crossbreds weighed 98 pounds more before calving but only 45 pounds more after weaning. The Angus scored 0.88 higher before calving and 1.68 higher after weaning. This shows that the crossbreds were larger in size, carried less condition throughout lactation and were very noticeably thinner after weaning. The crossbreds lost 59 pounds from before calving to after weaning compared to only a 7 pound loss by the Angus. Figure 1 shows the weight change curves of these 2-year-olds. Note that the Angus

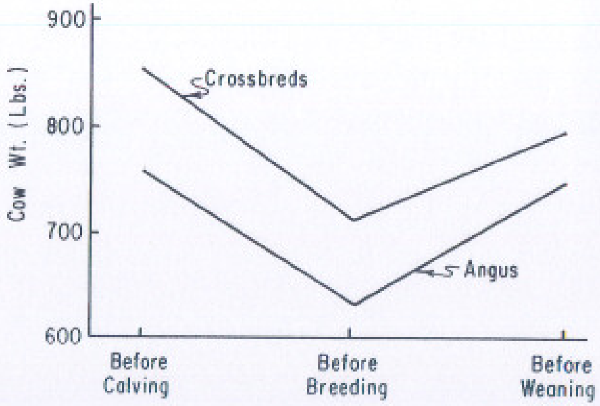

Figure 1. Weight change curves of first calf 2-year-old cows.

Table 4. Adjusted 205 Day Weaning Weights and Grades of Calves from Angus-Holstein (AXH) Crossbred and Grade Angus Dams.

Dam		Calf		Adj. 205 Day Wts.		Conformation		Condition	
Age (Yrs.)	Breed	Sex	No.	Ave. (lbs.)	SE[3]	Ave. Grade	SE[3]	Ave. Grade	SE[3]
2	Angus	Steer	10	386.0[1]	14.58	12.1	0.29	12.1	0.26
	AXH		24	438.7[2]	8.73	11.7	0.19	11.9	0.17
	Angus	Heifer	17	343.5[1]	11.18	11.6	0.23	11.9	0.24
	AXH		23	412.2[2]	8.92	11.5	0.21	12.0	0.20
3[4]	Angus	Steer	15	420.1[1]	11.90	12.0	0.24	12.0	0.21
	AXH		4	496.3[2]	21.38	12.8	0.45	12.4	0.41
	Angus	Heifer	12	383.1[1]	7.14	12.2	0.15	12.1	0.15
	AXH		9	461.4[2]	14.25	12.9	0.33	12.7	0.18

[1,2] Means with different superscripts within column within age of dam within calf sex are significantly ($P < .01$) different.
[3] Standard Error.
[4] No statistically significant difference in weaning weight, conformation, or condition was found due to previous reproductive performance of cows in either breed group. Thus, all calves of each breed-sex group represented in these means.

Table 5. Weights and Scores as 2 and 3-year-olds from Before Calving to After Weaning of Crossbred and Angus Cows that Nursed Calves

Dam			Before Calving				Before Breeding				After Weaning			
Age (Yrs.)	Breed	No.	Wts. (lbs.)	SE[2]	Score	SE[2]	Wts. (lbs.)	SE[2]	Score	SE[2]	Wts. (lbs.)	SE[2]	Score	SE[2]
2	Angus	27	759	12.1	4.30	.13	632	11.7	3.56	.13	752	15.9	4.04	.15
	AXH	41	857	12.2	3.42	.07	713	11.0	2.57	.11	798	12.0	2.36	.12
3	First Calf Angus	12	954	23.3	5.33	.25	792	11.5	3.54	.19	885	27.7	4.83	.34
	First Calf AXH[1]	10	1066	32.3	5.10	.16	892	29.7	3.04	.25	982	21.6	3.08	.27
	Second Calf Angus	15	778	20.8	3.60	.22	694	28.3	3.14	.20	845	27.3	4.00	.26
	Second Calf AXH[1]	3	908	58.9	3.00	.30	830	25.0	2.50	1.00	965	45.4	3.00	.54

[1] ¼ Augus-½ Holstein.
[2] Standard Error.

regained almost their entire calving weight loss by weaning time; but the crossbreds were not able to regain nearly as much of their loss. The greater weight loss and lack of recovery of the crossbreds may indicate the sacrificing of body weight for higher milk production.

For the 3-year-olds, those which did not nurse a calf as a 2-year-old because they did not breed or they lost their calf were separated for weight data analyses as first calf heifers from those which nursed calves both years (Table 5.). Figure 2 points out the greater 2-year-old weight gain of those which did not nurse calves and thus were heavier as 3-year-olds. Of the 3-year-old first calf heifers (Table 5), the crossbreds were significantly ($P<.05$) heavier at all three periods; but the condition scores were not statistically different even though the Angus scored slightly higher in each period. The crossbreds weighed 112 pounds more before calving and 97 pounds more after weaning. Both breeds lost 160-175 pounds (17 percent) from before calving to before breeding (May 1) which was comparable to the percentage loss of the 2-year-old first calf heifers. These 3-year-old first calf heifers also lost 70-85 pounds (7-8 percent) during the entire lactation which was comparable to the percentage loss of the 2-year-old crossbreds but more than the 2-year-old Angus.

In the 3-year-old second calf groups are cows that rebred after having their first calf as 2-year-olds; therefore, the number of crossbreds

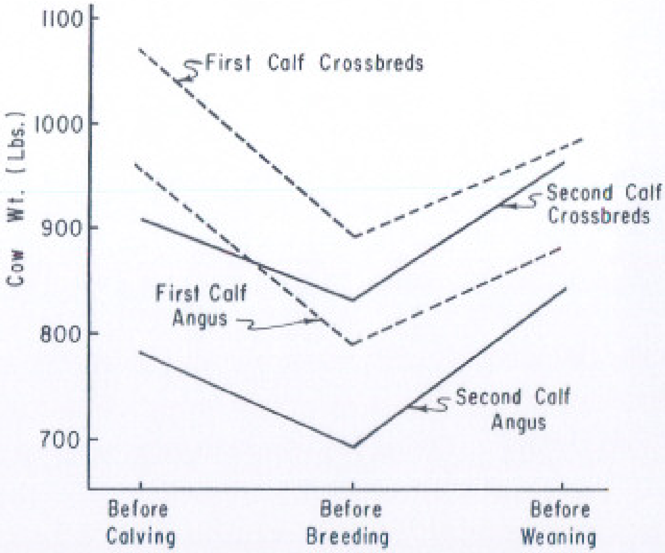

Figure 2. Weight change curves of first and second calf 3-year-old cows.

is quite small due to poor rebreeding. These crossbreds weighed 120-135 pounds more than the Angus at all three periods, but their scores were lower by .6 to 1.0. An interesting point (Figure 2) is that both breed groups of 3-year-old second calf cows lost only half the weight (about 80 pounds) that the 3-year-old first calf cows lost from before calving to before breeding. This represents a 9-11 percent loss for the second calf cows compared to a 17 percent loss for the first calf cows. This difference may have been due to the second calf cows weighing less before calving. Also the 3-year-old second calf cows gained about 60 pounds during their entire lactation which is considerably different from the losses of the first calf 2-and 3-year-olds. A higher level of nutrition was given the cows as 3-year-olds which could explain some of the differences between age groups, but this does not explain the differences within the 3-year-olds.

Figure 2 shows the weight change curves for all four groups of 3-year-old cows. From this graph a comparison within breed of the first and second calf cows can be made. The crossbred cows that had their first calf as 3-year-olds weighed considerably more (158 pounds) before calving than their contemporary second calf cows. However, this difference narrowed to 17 pounds after weaning. When comparing the 3-year-old Angus first to second calf cows, differences were found of 176 pounds before calving and 40 pounds after weaning. This narrowing of the difference after weaning is due to the greater loss of weight before breeding of the first calf cows and the greater weight gain during the summer for the second calf cows.

In summary, the crossbred cows were larger in size and carried less condition during their first and second lactations than the Angus. The first lactation was the most difficult time for both breeds of cows to maintain their weight and condition even if they calved first as 3-year-olds. It appeared that providing some additional feed early in lactation to 2-year-old crossbreds decreased their weight loss and increased conception rates. The condition scores of both breeds seemed to change in accordance with body weight.

Early Weaning Vs. Normal Weaning Vs. Creep-Feeding Of Replacement Heifer Calves

J. W. Holloway and Robert Totusek

Story in Brief

Approximately 200 Angus and Hereford females were subjected to (1) low (2) medium and (3) high planes of nutrition previous to weaning by (1) weaning at 140 days (2) weaning at 240 days, and (3) creep-feeding and weaning at 240 days, resulting in a 110 lb. range in average weight at 240 days of age.

Body weight, condition score and other measurements of growth were affected by preweaning treatment to 1.5 to 2.0 years of age, but differences were small after that time. The creep-fed females tended to wean lighter calves while the early weaned females tended to calve and wean a lower percent calf crop, especially for the first calf crop. The two breeds of females responded to preweaning plane of nutrition in a similar manner. Considering both productivity and cost of raising replacement heifers, the results of this experiment suggest that weaning at a normal age is preferable to either early weaning or creep-feeding.

Introduction

The development of replacement females with maximum productivity (milk production) and reproductive performance at a minimum cost is of utmost importance to the cow-calf industry in Oklahoma. The plane of nutrition during early life has been shown to affect the subsequent growth, reproduction and productivity of many species. The detrimental effects of a low plane of postweaning nutrition on the performance of beef cows has been recognized for many years, and more recently, the detrimental influence of a high plane of postweaning nutrition on beef cows has been clearly shown.

Limited observations at Oklahoma State University showed that heavy milking cows tend to produce heifer calves that develop into poorer producers than their dams while low milking cows tend to produce heifer calves that develop into better producers than their dams. These observations suggested that preweaning plan of nutrition influences subsequent performance of beef females. No controlled research, however, has been previously conducted with beef cattle in which differences in plane of nutrition were limited to the preweaning phase of the life cycle. This experiment was conducted to measure the influence of three preweaning planes of nutrition on the subsequent growth, lactation and reproductive performance of Angus and Hereford females. Both Angus and Hereford females were included in the experiment to determine if a breed difference exists. Previous research with dairy cattle indicate that early maturing breeds are more succeptible to the influence of preweaning plane of nutrition than late maturing breeds.

Procedure

Four groups of Angus and Hereford females (approximately 25 of each breed per group) were produced at the Lake Carl Blackwell Experimental Range near Stillwater. The first group was produced in 1963, the second in 1964, the third in 1965 and the fourth in 1966; the females were born in February, March and April each year.

Within each breed each year, three preweaning planes of nutrition were imposed on the heifer calves: (1) a low plane of nutrition was accomplished by weaning heifers at 140 days of age (early weaning), then maintaining a gain of approximately 0.75 lb. per day to an age of 240 days. During this period between 140 and 240 days of age, the 1963 females were on grass and supplemental concentrates, whereas the heifers produced in 1964, 1965 and 1966 were kept in a drylot and fed alfalfa hay. (2) A medium plane of nutrition was accomplished by weaning at 240 days of age (normal weaning). (3) A high plane of nutrition was accomplished by creep-feeding during the suckling period and weaning at 240 days of age. At 240 days of age the creep-fed heifers weighed 43 and 110 lb. more than the normal weaned and early weaned heifers, respectively; normal weaned heifers weighed 68 lb. more than early weaned heifers.

Differences in appearance of the heifers at 240 days of age were large and obvious as would be expected with an average range of 110 lb. in weight between the two extreme treatments. Early weaned heifers appeared rather frail while creep-fed heifers appeared to be considerably more growthy and were much thicker and deeper bodied; normal weaned heifers were intermediate in appearance.

All heifers in each trial were managed alike after the approximate age of 240 days. During the first winter after weaning they were maintained on a moderate plane of nutrition to gain approximately 0.50 to 0.75 lb. per head daily. Except as previously noted for the low level heifers between 140 and 240 days of age, all females were allowed to graze native pasture throughout the experiment, supplemented with protein concentrate or alfalfa hay during the winter. In each year all heifers of the same breed and year of birth were kept together and bred to the same bull (of the same breed as the females). Females were bred to calve first at 2 years of age and kept on experiment until 4.5 years of age by which time they had an opportunity to produce three calves. The calving season each year was March, April and May. Calves produced by the experimental females were not creep-fed and were not implanted with stilbestrol. They were weaned at an average age of six months.

Milk production of cows was estimated three to seven times each year by weighing calves before and after nursing.

Results and Discussion

Growth and Development.

Figure 1 illustrates the weight of females to 4.5 years of age as influenced by preweaning plane of nutrition. Differences were largest at 240 days of age, at which time the experimental treatments were terminated. The early weaned females tended to remain lighter than the other groups to 4.5 years of age, although the differences after 2 years of age was small (approximately 30 lb.). The weight advantage of creep-fed females dis-

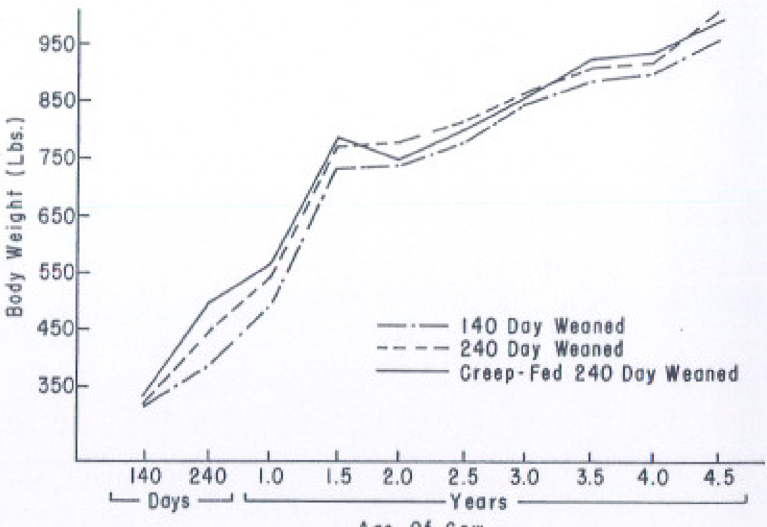

Figure 1. Average body weight of females fed different levels of nutrition before weaning.

appeared after 1.5 years.

Figure 2 illustrates changes in skeletal size as indicated by height at withers. At 240 days, creep-fed heifers were considerably taller (1.8 inches) than early weaned heifers, but only slightly taller (0.4 inch) than normal weaned heifers; the normal weaned heifers apparently made near-maximum growth and creep-feeding did little to increase skeletal size. On the other hand, the growth of heifers was noticeably slowed by early weaning. Appreciable differences in skeletal size existed through 1.5 years, but by the time of first calving (2 years) differences were small.

Other measurements of growth and fatness included circumference of heart girth, width at hooks, length of rump, length of body, distance from chest to ground, height at hooks and condition score. All indicators of growth followed a pattern similar to that outlined for body weight and height at withers, in that differences were largest at 240 days and gradually decreased to 1.5 years after which they were small.

The growth results of this experiment indicates that differences in size of heifers at normal weaning age created by plane of nutrition are temporary in nature, since differences after 1.5 to 2.0 years were either non-existent or small. There was definitely no permanent advantage in size of female due to creep-feeding, particularly compared to the normal weaned females. Early weaning did delay maturity as indicated by most body measurements, and appeared to cause a slight reduction in mature size; differences in size after 2.0 years were small but consistent.

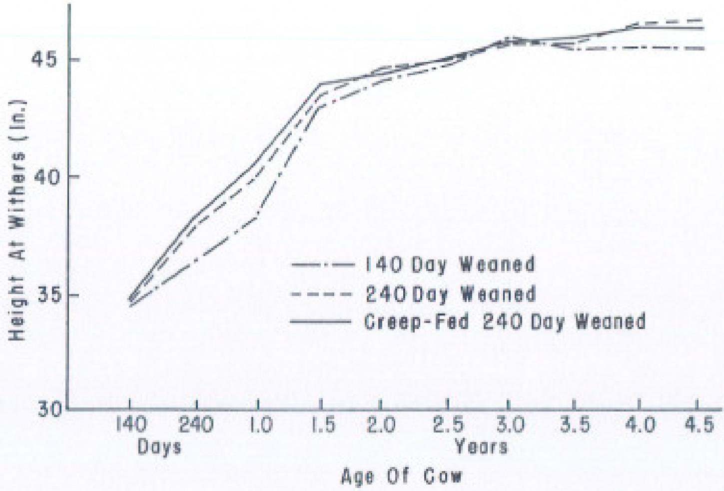

Figure 2. Average height at withers of females fed different levels of nutrition before weaning.

Reproductive Performance.

Average birth weight for all three calf crops of early weaned, normal weaned and creep-fed dams was 60.8, 62.5 and 63.4 lb., respectively (Table 1). The average birth weights suggest a slight trend for increased birth weight with increasing plane of preweaning nutrition. However, differences were small, and creep-fed females produced the heaviest calves the first and third calf crops but the lightest calves the second calf crop.

As shown in Figure 3 there was a general trend for a lower percentage of early weaned females to conceive, especially for the calf crop, as indicated by calving percent. For the first calf crop, the calving percent was 15.8 and 15.6 percent lower for the early weaned heifers than the normal weaned and creep-fed heifers, respectively. This indicates that more of the early weaned heifers had not reached sexual maturity during the first breeding season when the heifers were yearlings. The average calving percent for all three calf crops was 69.9, 76.9 and 79.8 percent for early weaned, normal weaned and creep-fed females, respectively (Table 1).

Percent calf crop weaned followed the same general pattern as calving percent; the average percent calf crop weaned for all three calf crops was 67.3, 72.8 and 76.8 percent (Table 1). As illustrated in Figure 4, the disadvantage of early weaned heifers in average percent calf crop weaned was due primarily to their low percent calf crop weaned for the first

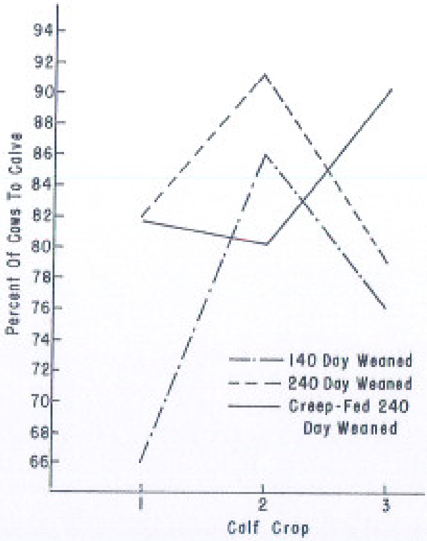

Figure 3. Average percent of cows which calved for three calf crops.

calf crop, which in turn was due entirely to their low calving percent. It can be concluded then that the major problem with early weaned heifers in this experiment was a failure of some heifers to reach sexual maturity before or during the first breeding season.

Calving percent and percent calf crop weaned were below normal for all groups. A contributing factor was the necessity to use one-bull breeding herds throughout the experiment; yearling bulls were used and in several instances it appeared bulls were of low fertility.

Calf Weight. As shown in Figure 5, the creep-fed females tended to wean lighter calves. Although rather consistent for all three calf crops, the differences were small, varying from 7 to 10 pounds. The average weaning weight for all three calf crops was 345, 341 and 335 lb. for early weaned, normal weaned and creep-fed females, respectively (Table 1).

Normal weaned females produced the most milk, and creep-fed females produced the least (Table 1). Although differences were small, some definite trends were evident. Twenty-four separate comparisons

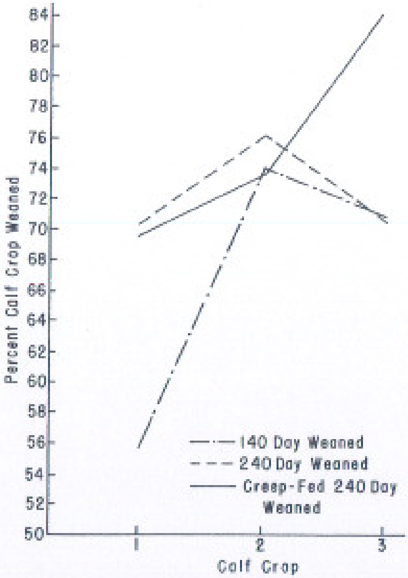

Figure 4. Average percent calf crop weaned for three calf crops.

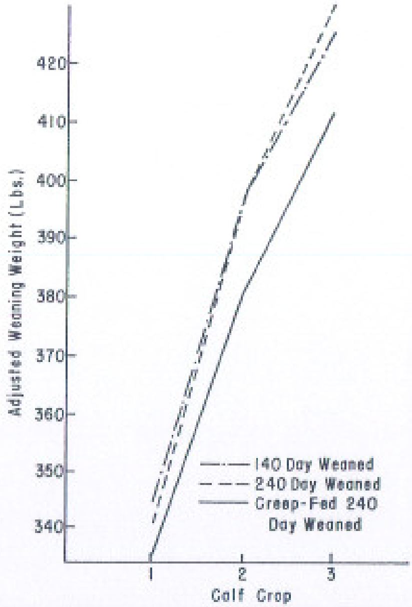

Figure 5. Average adjusted weaning weight of calves from cows fed different levels of nutrition before weaning (Adjusted to a 205-Day Steer Basis)

Table 1. Effects of Preweaning Plane of Nutrition on Cow Productivity Average for Three Calf Crops

	Preweaning Treatment of Cows[1]		
	Weaned at 140 days	Weaned at 240 days	Creep-fed, Weaned at 240 days
Birth wt.,[2] lb.	60.8	62.5	63.4
Calving percent	69.9	76.9	79.8
Percent calf crop weaned	67.3	72.8	76.8
Weaning wt.,[3] lb.	345	341	335
Pounds calf weaned per cow[4]	261	282	288
Estimated daily milk yield, lb.	9.6	10.1	9.2

[1] The preweaning treatment refers to the treatments imposed on the *cows* when they were heifers
[2] Adjusted to a bull calf equivalent.
[3] Adjusted to a 205-day, steer basis. Sex-adjustment was made by multiplying the age-adjusted weight of heifers by 1.05.
[4] Calculated by multiplying % calf crop × average weaning weight for each calf crop.

among preweaning treatments were possible within year-of-birth of experimental female, breed of experimental female and calf crop; in 16 comparisons normal weaned females produced more milk than early weaned females and in 18 comparisons creep-fed females produced less milk than normal weaned females. Furthermore, trends in milk production were similar to those observed for weaning weight, lending additional support to the concept that creep-feeding of replacement heifers is slightly detrimental to their future lactation ability.

The below-normal weaning weights observed in this experiment were caused in part by poor range conditions due to local drought, and by frequent handling of the calves during very hot weather which was necessitated by the procedures used for estimating milk production of the dams.

The average pounds of calf weaned per cow per year (sum of weaning weight x average percent calf crop weaned each calf crop) was 261, 282 and 288 for early weaned, normal weaned and creep-fed females, respectively (Table 1). The relatively poor performance of the early weaned females in pounds of calf weaned is primarily a reflection of their poor calving percentage for the first calf crop; they were at no disadvantage in terms of weaning weight of the calves which they produced.

Conclusions

The economic implications of this research are apparent. Although early weaning would normally involve essentially no additional expense (simply separate heifers from their dams and allow them to graze separate pastures), the decreased pounds of calf weaned due to the lower reproductive performance of early weaned heifers for the first calf crop suggest early weaning is a questionable practice. On the other hand, if pasture conditions and management were adequate to result in sufficient size of heifers to insure sexual maturity during the first breeding season, early weaning could probably be successfully practiced. Furthermore, if three-year-old calving is practiced, early weaning should be very satisfactory; three-year-old calving would eliminate the pressure of sexual maturity created by breeding heifers as yearlings.

An economic analysis of the results of this experiment does not favor the creep-feeding of replacement heifers. Creep-feeding of heifers did not produce a permanent advantage in size of the resulting cows and little distinct advantage in pounds of calf weaned. The creep-fed females in this experiment consumed an average of 430 lb. of creep-feed per heifer. At a cost of $65.00 per ton, the value of the creep-feed was $13.98. Assuming an average value of $0.40 per pound for calves, 35 lb. of additional calf per cow would be necessary to break-even. This is not likely to occur, especially considering the lighter calves produced by the creep-fed females. Further, the cost of creep-feed assumed above did not include a charge for labor and a creep-feeder. Economic implications may change slightly as prices change, but the fact remains that the creep-fed female has little if any advantage.

No relationship was noted between preweaning plane of nutrition and breed of female in this experiment. Even though the Angus females were slightly earlier maturing than the Herefords, they were not affected differently than the Herefords by preweaning treatment.

The results of this experiment suggest a general recommendation that for producing replacement females which will calve first at two years of age, weaning at a normal age is preferable to early weaning or creep-feeding.

The Performance Of Two-Year-Old Hereford, Hereford X Holstein And Holstein Females As Influenced By Level Of Winter Supplement Under Range Conditions

J. R. Kropp, D. F. Stephens, J. W. Holloway, Leon Knori, J. V. Whiteman and Robert Totusek

Story in Brief

The productivity of 2-year-old Hereford, Hereford x Holstein and Holstein females calving during November, December and January were compared under tallgrass range conditions. Two levels of supplemention (Moderate and High) were imposed on groups within each breed at calving and extended through the wintering period. One additional level of supplementation (Very High) was fed only to one group of Holstein females.

The amount of cow weight lost during the winter decreased as level of supplementation increased. The females which lost more weight during winter tended to gain more weight in the summer; the exception being the Holstein females. Condition scores closely followed the trends of winter weight losses and summer weight gains. The Holstein females produced heavier calves at birth than the other females. The 240-day sex-corrected weaning weights for the Angus x Hereford, Angus x Hereford x Holstein and Angus x Holstein calves were 504. 557 and 620 pounds, respectively. Average daily milk yield for the Hereford, Hereford x Holstein and Holstein females was 12.4, 18.3 and 24.3 pounds/day, respectively.

A definite trend existed for increased milk yields during the wintering period as level of supplementation increased within breed. The number of days from calving to first observed estrus and number of days from calving to apparent conception tended to decrease as level of supplementation increased. Poor reproductive performance was noted for the Moderate and High Holstein females. The Moderate Hereford females had the greatest dollar return above land and supplement costs. A level of supplement high enough to allow good rebreeding performance of Hol-

In cooperation with Ft. Reno Livestock Research Station, Agricultural Research Service, Animal Science Research Division, USDA.

steins resulted in a lower dollar return than noted for Hereford and Hereford x Holstein females.

Introduction

The milk production of beef cows is being increased in order to increase weaning weights of their calves. Selection on the basis of weaning weight results in selection for higher milk production, but milk production potential can be increased most rapidly by infusing genes for high milk production from animals of dairy breeding. Research has shown a strong correlation between level of milk production of beef cows and weaning weight of their calves.

The conversion of milk to calf gain is very efficient process. Within the limits of milk produced by beef cows, each additional 10 pounds of milk produces approximately an additional pound of calf gain. Research has indicated that conversion at high levels of milk production may not be as efficient. While it may be possible to greatly increase the level of milk production of range beef cows, the feed intake of the cow may be a limiting factor for greatly increasing total productivity. The purpose of this study was to determine the influence of varying levels of winter supplementation on actual milk yield, calf performance and reproductive efficiency of range brood cows differing widely in milk production potential.

Experimental Procedure

A groups of Hereford, Hereford x Holstein and Holstein heifers approximately one-year-old were assembled at the Fort Reno Livestock Research Station in the fall of 1969. A minimum of three herds were represented in the origin of each breed group. The heifers originated primarily from Oklahoma; however, some of the Holstein heifers originated in Wisconsin and some of the Hereford x Holstein heifers originated in Texas. For the ensuing year all heifers were maintained on tallgrass native range. The range on the Fort Reno station, classified in excellent condition, is little bluestem (Andropogon scerparus) predominantly and has a carrying capacity of approximately seven acres per cow-calf unit on a yearlong basis. The range forage is normally dormant from early November (first frost) to late April. Ample forage was available at all times.

All heifers received 2.0 pounds soybean meal (44 percent crude protein) per head daily from October 25, 1969 to April 30, 1970. The Holstein heifers received an additional 3.3 pounds ground milo per head daily to achieve a degree of body condition comparable to the Hereford and Hereford x Holstein heifers which received 2.0 pounds ground milo per head daily. All heifers were synchronized with CAP and bred artificially to a single Angus bull from February 15 to April 2, 1970 at which time they were pasture mated to three Angus bulls rotated bi-weekly among the three breeds until May 15, 1970. All heifers diagnosed open by pregnancy check in August, 1970 were sold and replaced with similar females from herds in Oklahoma. At calving (November 2, 1970 to January 26, 1971) each female was assigned to a level of winter supplementation on the basis of a preassigned calving order to equalize calving date within breed. The general design of the experiment is presented in Table 1.

The females within each breed were subjected to either two (Hereford and Hereford x Holstein) or three levels (Holstein) of winter supplementation designated as Moderate, High and Very High. The Moderate level consisted of that amount of supplemental feed deemed necessary to allow good rebreeding performance in the Hereford females. Previous experience at the Fort Reno Livestock Research Station suggested a winter weight loss (including weight loss at calving) from fall to spring of 10 to 15 percent would allow good rebreeding performance. The same level of supplement was fed to a group of Holstein females and to a group of Hereford x Holstein females. The High level was established by the Hereford x Holstein females and consisted of that amount of supplement estimated necessary to maintain their body condition and physiological activity comparable to that of the Moderate Herefords; this same level was fed to a group of Hereford females and to a group of Holstein females. The Very High level was established by the Holstein females and consisted of that amount of supplement estimated necessary to maintain their body condition comparable to Moderate Herefords and High Hereford x Holstein crossbreds; this level was fed only to Holsteins.

Table 1. Calving and Weaning Data

Item	Hereford		Hereford X Holstein		Holstein			SE[1]
	Moderate	High	Moderate	High	Moderate	High	Very High	
No. of calves	12	12	13	13	11	11	11	
Male	5	6	6	6	4	4	9	
Female	7	6	7	7	7	7	2	
Avg. calving date[2]	364[a]	364[a]	364[a]	353[a]	356[a]	358[a]	354[a]	6.4
Avg. birth wt., lb.	63.9[b]	64.2[b]	68.8[b]	64.2[b]	79.6[a]	81.8[a]	81.6[a]	2.4
Avg. adj. weaning wt., lb.	507[c]	500[c]	550[b]	563[b]	604[a]	621[a]	634[a]	14.5

[1] Approximate standard error, n = 12.
[2] Day of year, January 1, 1970 = 001.
a, b, c Means on the same line with differing superscripts differ significantly ($P < .05$).

The base breed-treatment groups were the Moderate Hereford, High Hereford x Holstein and Very High Holstein females which were fed an average of 2.6, 5.5 and 7.7 pounds/head/day post-calving of a 30 percent crude protein range supplement, respectively. Within each nutritional treatment, the quantity of supplement fed each female was adjusted for differences in body size on the basis of metabolic weight ($W^{.75}$). For example, an average weight Moderate Hereford and any Hereford x Holstein or Holstein female of the same weight on the Moderate level of supplementation was fed the same amount of supplement, but a lighter female received less and a heavier female received more (regardless of breed) in recognition of the fact that maintenance requirements are influenced by cow size.

The average daily supplement fed pre- and post-calving to each breed-treatment group is presented in Table 2. All females were individually fed the supplement five times per week (daily allowance x 7 ÷ 5) for a 172-day period from November 9, 1970 to April 30, 1971. Each breed-treatment group was maintained separately after cross-nursing was noted. Rotation among separate pastures was practiced at monthly intervals to minimize pasture effects on performance.

Individual cow weights were taken monthly from November, 1970 to November, 1971. Cow condition scores were taken just prior to initiation, just after termination and just before reinitiation of the supplemental feeding period. The condition scores were based on a scale of 1 (very thin) to 9 (very fat).

All calves were weighed and identified by ear tag within 24 hours after birth. The calves remained with their dams on native pasture until weaning and did not receive creep-feed. Calf weights were obtained after a six-hour shrink at monthly intervals during the lactation. All calves were weaned at 240 ± 7 days of age and weights were adjusted to 240

Table 2. Supplement Intake

	Hereford		Hereford X Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate	High	Very High
Supplement[1], lb.							
Total winter [2]	434.5	731.1	514.8	881.8	594.7	944.9	1203.2
Average daily, winter	2.5	4.3	3.0	5.1	3.5	5.5	7.0
Average daily, pre-calving	1.4	1.4	2.1	2.1	2.9	2.9	2.9
Average daily, post-calving	2.6	4.8	3.1	5.5	3.3	5.7	7.7

[1] Soybean meal (44%), 60.1%; milo, ground, 30.3%; dehydrated alfalfa meal, 5.0%; dicalcium phosphate, 2.9%; Masonex, 1.3%; salt, 0.5%; plus vitamin A added at 10,000 I.U./lb. of supplement.
[2] November 9, 1970 - April 30, 1971, 172 days.

days by interpolation (for calves weaned after 240 days of age) or extrapolation from past rate of gain (for calves weaned under 240 days of age). The age-corrected weaning weights of the heifer calves were corrected to a steer equivalent by multiplying by 1.05.

The estimated 24-hour milk production of the females was determined by the calf-suckle technique. The first estimate was made in late December, 1970 with subsequent estimates taken at approximately monthly intervals until seven estimates had been made for each female. The calves were weighed to the nearest 0.1 pound immediately before and after nursing; the difference in calf weight represented the estimated milk yield for a six-hour period. Four six-hour estimates were combined to give a 24-hour estimate of milk yield.

All females observed in estrus were artificially inseminated to one Charolais bull for 23 days beginning February 17, 1971, then hand mated for 22 days and pasture exposed for 45 days to three half-sib Charolais bulls. Rebreeding performance was evaluated on the basis of date of first observed estrus, date of apparent conception and pregnancy determined by rectal palpation approximately 90 days after the breeding season terminated.

Results and Discussion

Cow Weight and Condition.

A significant ($P < .01$) treatment effect was noted for winter weight loss; the amount of weight loss decreased as level of supplementation increased (Table 3). Hereford females which lost more weight in the winter tended to gain more weight during the summer; a trend in agreement with previous results with spring calving Herefords at the Fort Reno Station. It is interesting to note that this trend was not observed with the Hereford x Holstein females and particularly with the Holstein females. In fact, the Moderate Hereford x Holstein and Moderate Holstein females only regained their winter weight loss and consequently did not increase in weight as normally observed between 2 and 3 years of age.

Condition scores closely followed the trends of winter weight losses and summer weight gains with the mid-lactation condition scores decreasing as level of supplementation decreased. The Moderate treatment showed a compensating effect (larger increases than the High or Very High treatments) when adequate nutrition was available during the summer grazing season. A significant ($P < .01$) treatment effect for spring condition scores existed with the High females exhibiting more external fatness than the Moderate females.

The cow weights by period, including pre-partum, lactation and post-lactation are presented graphically in Figure 1. All breed-treatment

Table 3. Weight, Weight Change and Condition Data

Item	Hereford Moderate	Hereford High	Hereford X Holstein Moderate	Hereford X Holstein High	Holstein Moderate	Holstein High	Holstein Very High	SE[1]
Weight, lb.								
Fall, 1970 (pre-calving)	885^{c}	904^{c}	988^{b}	995^{b}	1151^{a}	1090^{a}	1116^{a}	26
Spring, 1971 (mid-lactation)	753^{c}	788^{c}	813^{bc}	882^{ab}	946^{a}	917^{a}	954^{a}	26
Fall, 1971 (post-lactation)	985^{b}	983^{b}	993^{b}	1055^{b}	1152^{a}	1156^{a}	1200^{a}	28
Weight change, lb.								
Winter	-132^{ab}	-116^{a}	-175^{cd}	-113^{a}	-205^{d}	-173^{cd}	-162^{bc}	13
Summer	232^{ab}	195^{c}	180^{c}	173^{c}	206^{bc}	239^{ab}	246^{a}	13
Year[3]	100^{a}	79^{a}	5^{b}	60^{a}	1^{b}	66^{a}	84^{a}	
Wt. change (%)								
Winter	-15	-13	-18	-11	-18	-16	-15	
Summer	31	25	22	20	22	26	26	
Year	11	9	0	6	0	5	7	
Condition score[2]								
Fall, 1970 (pre-calving)	6.17^{a}	6.33^{a}	5.00^{b}	5.08^{b}	4.27^{c}	3.55^{c}	4.27^{c}	0.25
Spring, 1971 (mid-lactation)	4.83^{b}	5.58^{a}	3.85^{c}	4.77^{b}	2.09^{e}	2.09^{e}	3.09^{d}	0.27
Fall, 1971 (post-lactation)	5.25^{a}	5.58^{a}	4.38^{b}	4.69^{b}	3.36^{d}	3.00^{d}	3.73^{c}	0.20

[1] Approximate standard error, n = 12.
[2] Condition score: very thin = 1, ... , very fat = 9.
[3] Significant treatment effect ($P < .01$).
a, b, c, d, e Means on the same line with differing superscripts differ significantly ($P < .05$).

groups tended to increase in body weight until calving and then showed a drastic reduction in weight associated with calving loss. All cattle continued to lose weight during the wintering period and reached their lowest weight during the fifth or sixth periods (third or fourth months of lactation, March to April on the average) after which a steady increase in weight until weaning was noted. There was a trend for the weight curves of the three breed groups to remain separate throughout the year. There were no significant differences in weight between treatments within a breed for any period during the year.

Calf Weight.

The mean birth weights and 240-day sex-corrected weaning weights are presented in Table 1. The Angus x Holstein calves were significantly heavier ($P < .001$) at birth than the Angus x Hereford x Holstein and Angus x Hereford calves. Since all females were bred to common Angus

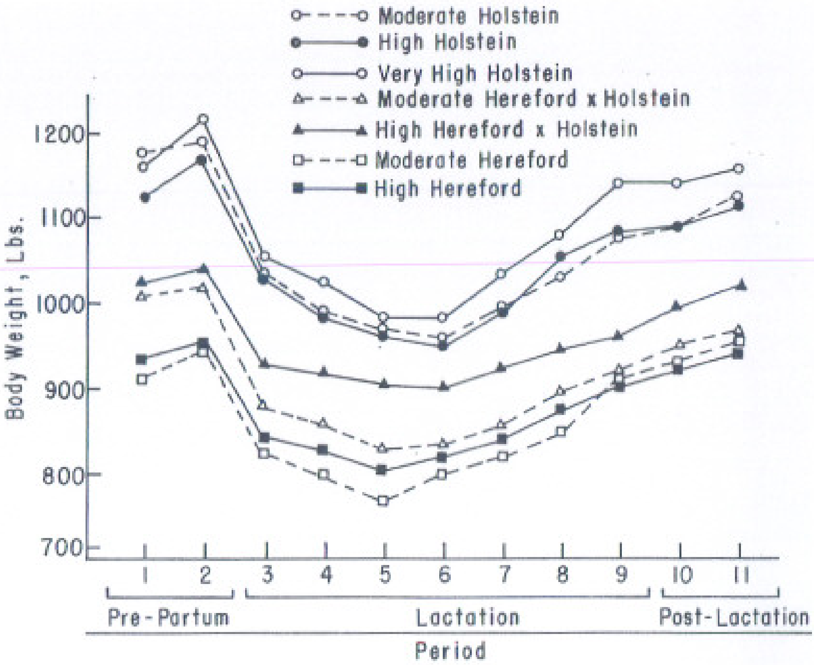

Figure 1. Average body weight curves.

bulls, these differences in birth weight were probably due to the larger body size of the Holstein females which weighed significantly ($P < .01$) more than the Hereford x Holstein and Hereford females. At weaning, the Angus x Holstein, Angus x Hereford x Holstein and Angus x Hereford calves weighed 620, 557 and 504 pounds, respectively. All differences in weaning weight among the three breed groups were highly significant ($P < .01$), but there were no significant treatment differences within breed.

Milk Yield.

The Holstein females produced the greatest entire lactation milk yield, followed by the Hereford x Holstein and Hereford females (Table 4). All differences in milk yield among breeds were highly significant ($P < .001$). Lactation curves for the three breed groups remained separate throughout lactation; this indicated that three different milk production potentials had indeed been established by the three breeds of females used in this experiment. For the Holstein females, no level of supplement appeared to be superior or inferior to the other levels except for periods 3

Table 4. Milk Production Data

Item	Hereford		Hereford X Holstein		Holstein			SE[1]
	Moderate	High	Moderate	High	Moderate	High	Very High	
Total lactation yield, lb.	2880	3096	4152	4632	5640	5880	5952	
Daily yield, lb.[2]	12.0[d]	12.9[d]	17.3[c]	19.3[b]	23.5[a]	24.5[a]	24.8[a]	0.74

[1] Approximate standard error, n = 12.
[2] Significant treatment effect (P< .05).
a, b, c, d Means on the same line with differing superscripts differ significantly (P< .05).

and 4 during which the Moderate Holsteins produced significantly less (P < .01) milk than the Very High Holsteins. The treatment lactation curves for both the Hereford x Holstein and Hereford females tended to remain separate with the High females producing somewhat higher levels of milk; however, these differences were nonsignificant (P>.05).

The lactation curves observed in this experiment were much flatter than many previously reported, possibly due to the availability of spring grass at the time when milk yields normally decline as well as the generally excellent grass conditions throughout the summer 1971 grazing

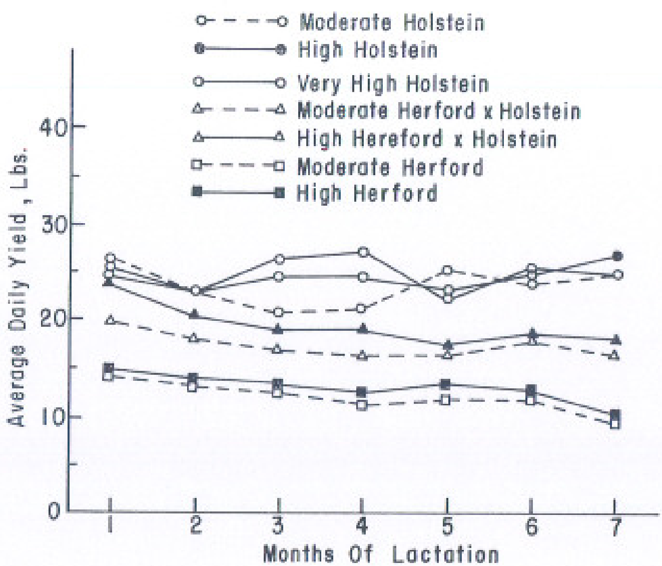

Figure 2. Average daily milk yield.

season. The Holsteins actually produced as much milk during late lactation as during early lactation, perhaps caused by the limited capacity of the calf for milk in early lactation.

The milk production of all breed-treatment groups was influenced by the imposed nutritional treatments as well as the seasonal quality of the forage. There was a definite trend for increased milk yields during the wintering period as level of supplementation increased within breed. A significant ($P < .01$) treatment effect for milk yield was noted during periods 3 and 4 (March and April) when the forage was extremely mature, weathered and of lowest quality and level of supplementation should have had its greatest effect. Reduced protein and/or energy intake have been shown to result in reduced milk yields for several months after termination of winter supplementation; however, in this experiment females wintered at the lower levels generally showed a slightly greater increase in milk yield when spring grass became available.

Reproductive Performance.

There were no significant differences among breeds for days to first observed estrus or days to apparent conception (Table 5). There was a definite trend for the number of days to first observed estrus and the number of days to apparent conception to decrease as level of winter supplementation increased. All Hereford, Hereford x Holstein and Very High Holstein females rebred. Only 8 out of 11 Moderate Holstein fe-

Table 5. Reproductive Performance Data

	Hereford		Hereford X Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[1]
No. of females	12	12	13	13	11	11	11	
No. of females exhibiting estrus	12	12	13	13	8	9	11	
Days post-partum to first observed estrus[2]	71^{a}	62^{a}	82^{b}	68^{a}	83^{a}	71^{a}	65^{a}	8.1
Days post-partum to apparent conception[3]	78^{ab}	75^{a}	100^{b}	94^{ab}	89^{ab}	90^{ab}	77^{ab}	8.1
No. of females bred	12	12	13	13	8	9	11	

[1] Approximate standard error, n = 12.
[2] Based only on those females which exhibited estrus.
[3] Based only on those females that conceived.
[a,b] Means on the same line with differing superscripts differ significantly ($P < .05$).

males and 9 out of 11 High Holstein females rebreed during the 90-day breeding season. These females were never observed in estrus; therefore, the Moderate and, possibly, High levels of supplementation appeared to be too low to support maximum reproductive performance in 2-year-old Holsteins under range conditions even when ample forage was available at all times.

Economic Analysis.

The results of any economic analysis depends on the prices which are assumed. Different prices can be substituted by anyone at any time.

An economic analysis of returns above land and supplement costs is presented in Table 6, based on assumptions which will be described. Cost of the native range was estimated to be $50.00 per year per female for the Moderate Herefords. A drylot trial involving the same breed-treatment groups as this experiment was conducted concurrently. Individual roughage intakes were determined in the drylot trial and served as the basis for estimation of forage consumption of the range cows. The percent of forage consumed by each breed-treatment group in drylot compared to that of the Moderate Herefords was multiplied by $50.00 to estimate the land cost of each group. The cost of the supplement was estimated at $85.00/ton.

The calves from the Hereford, Hereford x Holstein and Holstein females were estimated to be worth $41.00, $39.00 and $37.00/cwt for steers and $36.00, $34.00 and $32.00/cwt for heifers, respectively. Estimated calf value was calculated by multiplying the actual weaning weight of the steer and heifer calves by their respective price/cwt. and then calculating an unweighted steer-heifer average.

Table 6. Economic Analysis

	Hereford		Hereford X Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate	High	Very High
Land requirement, %[1]	100	102	118	112	147	146	136
Land cost per female, $	50.00	51.00	59.00	56.00	73.50	73.00	68.00
Supplement cost per female, $	18.47	31.07	21.88	37.48	25.27	40.16	51.14
Total land and supplement cost, $	68.47	82.07	80.88	93.48	98.77	113.16	119.14
Average value of calf, $	190.72	188.27	196.14	198.51	203.52	210.12	209.47
Return above land and supplement cost, $	122.25	106.20	115.26	105.03	104.75	96.96	90.33

[1] Expressed as % of Moderate Herefords as determined by forage intake in a drylot trial.

The Moderate Hereford females returned the most profit above land and supplement costs ($122.25), followed by Moderate Hereford x Holsteins ($115.26). Feeding the High level of supplementation to either Herefords or Hereford x Holsteins decreased profits by $16.05 and $10.23, respectively. The Holstein females returned the lowest profit and will show an additional loss in the next calf crop due to a failure of some females to rebreed in the Moderate and High groups. All Very High Holsteins rebred, but the high cost of supplementation in this group decreased profit; however, it may represent the level of supplementation necessary for 2-year-old Holsteins under range conditions.

Summary

Results of this study indicate that 2-year-old Hereford x Holstein females are capable of producing more milk and weaning heavier calves with comparable reproductive performance on the same level of supplement as Hereford females when ample forage is available, but due to their larger body size require more forage (acres) per cow-calf unit. The Holstein females were superior to the other breeds in this study in milk yield and calf weaning weights, but were at some disadvantage due to increased forage (acreage) requirement per cow-calf unit, poor reproductive performance at low levels of supplementation and high supplement costs at the highest level of supplementation.

Observations On Increasing Pay-Weight of Calves From Angus And Hereford Cows By Combining Several Known Management Practices

Robert Totusek, Ivan Rush and W. E. Sharp

Story in Brief

Angus and Hereford cows produced straightbred calves not implanted with stilbestrol the year previous to this study with a weaning weight of 420 pounds at 186 days for steers and 399 pounds at 193 days for heifers.

In this study Charolais crossbred heifer calves produced within the same group of cows averaged 607 and 536 pounds at 263 and 216 days of age. The Charolais crossbred steer calves, implanted with stilbestrol, averaged 719 and 552 pounds at 269 and 209 days.

The observations summarized in the report indicate that several known management practices (crossbreeding, stilbestrol implantation, weaning at an older age) can be combined to greatly increase pay-weight of calves

Introduction

The cow-calf operator has been caught in a serious cost-return squeeze in recent years. Cattle prices are now at a level similar to those of 20 years ago, and for most of the past 20-year period cattle prices have been considerably below those of 1951. During the same 20-year period many costs of production have doubled or tripled. Obviously, net returns have decreased.

One soultion to the cost-return squeeze is to increase the total dollar value of calves at weaning. If the increase in total dollar value of calves at weaning exceeds any accompanying increase in costs of production, a greater net return will result.

Appreciation is hereby expressed to Mr. Mack Braly, Oklahoma Charolais Ranch, Stonewall, Dr. J. T. Terry, Ponca City, and Mr. Frank Leven, Newkirk, for providing the services of Charolais bulls.

This report shows the increase in weaning weight of calves which resulted from crossbreeding, implanting steers with stilbestrol, and weaning calves at an older age.

Procedure

A total of 85 Angus and Hereford cows had been previously involved in an experiment in which cows were bred to bulls of the same breed to produce straightbred calves, implanting calves with stilbestrol was not practiced, and the calves were weaned at 6 months of age. For the purposes of the observations reported herein the cows were bred to Charolais bulls, steer calves were implanted with stilbestrol, and the calves were weaned at an older age.

Cows were 5 to 7 years old when they produced the calves summarized in this report. A portion of the cows (12 Angus and 16 Hereford) had calved in late spring 2 years previous and were held open for 7 months and bred to calve in November and December (fall calves). The other cows calved in January, February and March (spring calves). Cows were pasture-bred to four Charolais bulls. Three of the bulls were 16 months old at the beginning of the breeding season, while the other bull was a 4-year-old.

The fall calves received pelleted alfalfa meal as a creep-feed for a 106-day period from January 8 to April 24; the total intake per calf during this period was 46 pounds. Spring calves were not creep-fed. Each steer calf received one 12-milligram implant of stilbestrol in the ear in April. Heifer calves were not implanted. Fall calves were weaned September 2, spring calves September 22, 1971.

Results and Discussion

The excellent reproductive performance of Angus and Hereford cows producing crossbred Charolais calves is shown in table 1. No calves were pulled. One calf was stilborn and another died shortly after birth, for a total loss at calving of only two calves out of 85 cows. Part of the freedom from calving difficulty can be attributed to the fact that all cows were mature. In addition, the bulls which were used were not extremely large, rugged bulls, but rather were medium-sized, neat-fronted Charolais bulls. They were definately of a type less suspect to cause calving difficulty than coarser kinds of bulls.

Birth weight of the Charolais crossbred calves ranged from 55 to 110 pounds and averaged 78 pounds, which was 8 pounds heavier than straightbred calves produced by the spring-calving cows the previous year. This was less increase in birth weight than would be expected from

Table 1. Reproductive Performance of Angus and Hereford Cows Producing Charolais Crossbred Calves

Breed of cow and season of calving	No. cows	No. calves pulled	No. calves lost at birth	No. calves weaned	Birth weight of calves, lb. — Charolais crossbreds — Bulls[1] Avg.	Bulls[1] Range	Heifers[1] Avg.	Heifers[1] Range	All calves[2]	Previous year as straightbreds[2]	No. cows rebred
Angus											
Fall	12	0	0	12	70	61-73	72	64-83	73	--	11
Spring	34	0	0	33	76	56-94	75	60-87	77	67	33
Total	46	0	0	45	74	61-94	74	60-87	76	--	44
Hereford											
Fall	16	0	1	15	84	67-110	74	65-89	81	--	16
Spring	23	0	1	20	78	70-98	77	55-89	79	76	22
Total	39	0	2	35	81	67-110	76	55-89	80	--	38
Both breeds											
Fall	28	0	1	27	78	61-110	73	64-89	77	--	27
Spring	57	0	1	53	76	56-98	76	55-89	78	70	55
Total	85	0	2	80	77	56-110	75	55-89	78	--	82

[1] Actual birth weight.
[2] Adjusted to a bull equivalent by multiplying heifer weight by 1.048.

some Charolais bulls, and offers additional explanation for the freedom from calving trouble which was observed. Birth weight of calves from Angus cows increased more than that of calves from Hereford cows, compared to the previous year when calves were straightbreds.

Weaning weight information is summarized in Table 2. The adjusted weaning weight of Charolais crossbreds compared to straightbreds produced by the same cows the previous year provides some indication of the benefit gained by the use of Charolais bulls for crossbreeding. The advantage for the Charolais crosbreds was 70 and 55 pounds for Angus and Herefords, respectively, and an average of 65 pounds for all calves. Since the calves being compared were not produced in the same year, it should be recognized that a year effect (weather, grass conditions) could also have been involved. In addition, the cows were 1 year older in this trial.

It is particularly interesting to consider actual weaning weights in comparison to weights the previous year. The spring-calving cows produced straightbred calves the previous year with a weaning weight of 420 pounds at 186 days for steers and 399 pounds at 193 days for heifers. In contrast, the actual weaning weight of spring calves (both breeds combined) in the present calf crop was 552 pounds at 209 days for steers and 536 pounds at 216 days for heifers. These advantages in weaning weight included benefits of crossbreeding, implantation of steers with stilbestol, and a slightly older weaning age.

Especially dramatic were the actual weaning weights of the fall calves, which benefited from the same items as the spring calves plus considerably more age. The fall calves were about 9 months old (266 days) when weaned. Although the dams of these calves had the advantage of a 7-month rest before being rebred to produce these calves, they were possibly at some disadvantage from the standpoint of producing fall calves. The fall steer calves (both breeds combined) averaged 719 pounds at weaning, an advantage of 167 pounds over the spring steer calves. The fall and spring steer calves gained 2.38 and 2.27 pounds per day, respectively, from birth to weaning. Perhaps the fall calves, being older, were able to utilize summer grass more effectively and/or received more benefit from stilbestrol. The fall steer calves gained approximately 2.41 pounds per day during July and August, at an age between 7 and 9 months. An excellent ration would have ben required to produce a comparable rate of gain had the calves been weaned at 7 months of age, and surely the cost of gain would have been higher. Fall heifers with a weaning weight of 607 pounds were 71 pounds heavier than spring heifers.

These results suggest that consideration should be given to weaning fall dropped calves at an older age than sometimes practiced to realize maximum calf gain from forage. This would be particularly desirable for

Table 2. Weaning Performance of Angus and Hereford Cows Producing Charolais Crossbred Calves

	No. calves	Weaning weight of Charolais crossbreds: Actual: Steers: Age, days	Wt., lb.	Heifers[2]: Age days	Wt., lb.	All calves: Age, days	Wt., lb.	Adjusted,[3] lb.	Weaning weight previous year as straightbreds: Actual: Age, days	Wt., lb.	Adjusted,[2,3] lb.
Angus											
Fall	12	269	710	268	631	268	664	512	---	---	---
Spring	33	212	561	219	543	216	552	515	192	407	445
Total	45	226	596	233	569	230	582	515	---	---	---
Hereford											
Fall	15	269	726	259	585	264	651	509	---	---	---
Spring	20	204	536	211	524	208	530	511	187	410	456
Total	35	232	619	232	550	232	581	510	---	---	---
Both Breeds											
Fall	27	269	719	263	607	266	657	510	---	---	---
Spring	53	209	552	216	536	213	543	514	190	408	449
Total	80	229	606	233	560	231	582	513	---	---	---

[1] Implanted with stilbestrol

[2] Non-implanted.

[3] Adjusted to a 205-day, steer, mature dam, no stilbestrol basis. Adjustment was made for stilbestrol by multiplying weights of implanted calves by 0.95, based on previous research which indicated an average benefit of 5 percent in weaning weight from implanting with stilbestrol.

a producer who finishes his calves for slaughter, because he could capitalize on cheap gains and would not be concerned with a possible discount for heavy calves. Feedlot gains subsequent to weaning heavy calves might be costlier, but total gain would very likely be cheaper.

This trial did not involve a controlled comparison to demonstrate the value of implanting suckling calves with stilbestrol. However, much previous research at this station has shown that implanting steer calves with stilbestrol results in an average of 25 additional pounds at weaning.

At weaning the steer calves from this study were either placed in a feedlot or on a stocker program previous to being placed in a feedlot. Their postweaning performance will be reported later.

Conclusions

The observations herein reported suggest that several known management practices can be combined to greatly increase the pay-weight of calves.

Self-Fed Dry and Liquid Supplements Containing Natural Protein and Non-Protein-Nitrogen For Wintering Range Cows

Ivan Rush, W. E. Sharp and Robert Totusek

Story in Brief

Hereford and Angus cows wintered on a dry 30 percent all-natural protein supplement lost less weight and had higher condition scores than cows on a dry supplement containing 15 percent all-natural protein, or 30 percent supplements in which one-half of the protein equivalent was provided by urea or biuret.

Cows wintered on a liquid 30 percent protein supplement lost considerably more weight and had lower condition scores than cows wintered on the dry 30 percent all-natural protein supplement, even though more liquid supplement was consumed. Cows on liquid cane molasses consumed twice as much liquid cane molasses as liquid supplement and lost slightly less weight and were in poorer condition at the end of the experiment than the liquid supplement cows.

Weight and condition of cows in this experiment indicated that utilization of urea in dry and liquid supplements and biuret in a dry supplement was poor, and underscored the need for finding methods for improving the utilization of non-protein-nitrogen at high levels in range supplements.

Salt was effective in controlling intake of dry self-fed supplements at a desired level, but the self-feeding of supplements did not result in the utilization of non-protein-nitrogen at a satisfactory level.

Introduction

Wintering feed costs represent one of the major expenses in a cow-calf operation and cattlemen are continually seeking ways of lowering this cost. Non-protein-nitrogen (NPN) sources, especially urea, are extensively used in feedlot rations as a replacement for natural protein and

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have lowered the cost of protein supplement. However, research has shown that utilization of urea by range cows is disappointingly poor, and methods for utilizing relatively high levels of urea and other NPN in range supplements need to be developed.

The use of NPN can lower the cost of range supplements. The increasing human demand for natural protein will increase the price spread between natural protein and NPN in the future.

Results with urea in range supplements, particularly at high levels, have generally been poor. Some of the problems associated with urea in range supplements are: (1) It is broken down in the rumen at such a rapid rate that the bacteria are not able to utilize all the resulting ammonia to synthesize protein so a considerable amount of it's potential protein value is lost. (2) Dry winter grass is very low in readily available energy, which is needed for good conversion of ammonia to protein. (3) When high levels of urea are fed toxicity problems can develop under certain conditions. (4) Palatability may be a problem when high levels are fed. In view of the above problems, urea is presently omitted from range supplements or is used at levels to furnish only 10-30 percent of the protein equivalent of the supplement. Higher levels of urea would be desirable to further decrease the cost of supplements.

Considerable research has been conducted in search of sources of NPN without the disadvantages of urea which could be utilized by cattle to synthesize protein. Biuret is a NPN compound that shows considerable promise as a protein substitute in range supplements. Biuret is broken down more slowly in the rumen, and it is reported to be more palatable. One possible disadvantage of biuret is that a longer period of adaptation may be required for biuret than urea; the bacteria in the rumen must become adapted to biuret before it can be utilized for protein synthesis.

Another item of considerable expense and an increasing problem for cattlemen is labor. Labor output may be reduced by self-feeding supplements. Research at the Oklahoma Experiment Station and elsewhere during the past 20 years has shown that salt can be used to effectively control the level of intake of feeds. The use of salt to control the intake of supplements relatively high in NPN has not been investigated. It has been theorized that the self-feeding of supplements containing NPN will improve NPN utilization due to the intermittent release of ammonia.

Another method of self-feeding protein supplements to range cattle which has gained popularity throughout the country is the use of liquid supplements. One of the major advantages of liquid supplements is the convenience of feeding, as many feed dealers will deliver the supplement to the self-feeding tank. Most liquid supplements are formulated in a molasses base and contain urea as the major nitrogen source. Phosphoric acid is usually added as a phosphorus source and to control intake, and liquid supplements contain various vitamins, minerals and in some cases antibiotics or other additives.

The purpose of this trial was to compare supplements containing natural protein to supplements containing urea or biuret. Also dry self-fed supplements were compared to liquid self-fed supplements.

Procedure

The experiment was conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage is of the tallgrass prairie type with the climax species consisting of little bluestem, big bluestem, Indian and switch grasses. Since these grasses were dormant during the wintering trial the major portion of the cows' diet consisted of dry weathered grass. Prairie hay was fed only on a few occassions when snow covered the range forage.

The experimental cattle were mature Hereford and Angus cows 4 to 6 years old at the beginning of the trial. All cows included in the trial had been bred to Charolais bulls; cows started calving the latter part of January and calved throughout the trial.

The experiment was conducted during an 84-day period from December 5, 1970 to February 27, 1971. The cows were rotated to different pastures at 28-day intervals to minimize differences in performance due to possible pasture differences. Six different supplements were fed; all were self-fed. Four supplements were dry and two were liquid. The ingredient make-up of the dry supplements is shown in Table 1. Supplement 1 contained 30 percent, all-natural protein. Supplement 2, containing 15 percent natural protein, was fed as a negative control. Supplements 3 and 4 contained 30 percent protein equivalent; one-half of the total protein, 15 percent, consisted of natural protein whereas urea or

Table 1. Ingredient Makeup of Dry Supplements

Lot Supplement Crude protein, %	1 Natural 30	2 Natural 15	3 Urea 30	4 Biuret 30
Dehydrated alfalfa meal	5.00	5.00	5.00	5.00
Milo, ground	33.00	72.77	63.06	61.46
Soybean meal (44% protein)	56.83	17.44	19.42	19.87
Dicalcium phosphate	0.88	1.28	1.27	1.27
Monosodium phosphate	3.28	3.51	3.58	3.59
Sodium sulfate	----	----	2.35	2.35
Urea (45% nitrogen)	----	----	5.31	----
Biuret[1] (37% nitrogen)	----	----	----	6.46
Vitamin A[2]	+	+	+	+

[1] Kedlor, a feed grade source of biuret.
[2] Added at a level of 10,000 I.U. per lb. of supplement.

biuret furnished the remaining 15 percent (one-half) of the protein equivalent. Supplement 2, the negative control, served two purposes. First, the difference in performance between cows receiving supplement 1 (30 percent protein) and supplement 2 (15 percent protein) would indicate if additional protein were needed beyond that amount provided by supplement 2. Second, the performance of cows fed either supplement 3 or supplement 4, in comparison to cows fed supplements 1 *and* 2, should provide some indication of the degree of utilization of urea or biuret.

The four dry supplements were formulated to contain 1.5 percent phosphorus, 0.5 percent calcium and the nitrogen-sulfur ratio was approximately 14:1.

The consumption of the dry supplements was controlled by adding various levels of salt. The range in salt levels used in the supplement-salt mixtures to accomplish similar levels of supplement intake is shown in Table 2.

Supplement 5 was a liquid supplement containing 30 percent crude protein; it was available to the cattle at all times. Aluminum sulfate was added to the liquid supplement for a short time in the early phase of the experiment to prevent overconsumption when initial intake was high (7 to 8 lb. per cow daily).

Table 2. Supplement Consumed, Winter Weight Change and Condition Score of Cows Wintered on Various Range Supplements[1]

Lot Supplement Crude Protein, %	1 Natural 30	2 Natural 15	3 Urea[2] 30	4 Biuret[3] 30	5 Liquid[4] 30	6 Molasses 3
No. of cows	10	10	9	9	9	9
Daily supplement, lb.[5]	2.60	2.69	2.93	2.71	3.42	6.80
Salt in mixture,%	25.0-29.5	23.3-25.0	20.0-25.0	20.0-20.8	----	----
Wt. per cow, lb.						
12-5-70 (initial)	1075	1036	1026	1052	1023	1063
1-2-71	1063	1058	1024	1052	1018	1049
2-26-71 (final	953	858	870	876	837	886
No. cows calved by 2-27-71	7	8	4	8	4	5
Wt. change per cow[6]						
lb.	—122	—178	—156	—176	—186	—177
percent	—11.4	—17.2	—15.2	—16.8	—18.2	—16.7
Condition score[7], 2-27-71	4.0	3.6	3.5	3.4	2.9	2.2

[1] Cows were grazed on dry native grass.
[2,3] To furnish one-half of protein equivalent.
[4] Approximately 90% of protein equivalent from urea.
[5] Not including salt.
[6] Since the number of cows which calved by the completion of the test period was not equal among lots, and since calving involves considerable weight loss, all weight change figures were adjusted to a common basis compared to the negative control, Lot 2. Therefore, the winter weight change figure is a weighted value, calculated by the following formula:
Av. winter weight change of the lot = Av. weight change of cows which calved X 80% + Av. weight change of cows which did not calve X 20%.
[7] On a scale of 1-9, with 1 the thinnest and 9 the fattest.

Supplement 6 was liquid cane molasses. It was included in the experiment to serve as a negative control for the liquid supplement; since molasses contains little protein (3 percent) but a similar level of energy as liquid supplements, the relative performance of cows consuming liquid supplement and molasses should offer some indication of the degree of utilization of urea in the liquid supplement. Aluminum sulfate was added to the molasses throughout the experiment in an attempt to limit consumption.

At the conclusion of the experiment cows were scored for condition on a scale of 1 to 9, with 1 being the thinnest and 9 the fattest.

The supplement feeding comparison was terminated on February 27, at which time all cows were divided into two breeding groups and fed a natural-protein supplement until April 20. Calves were weaned on September 22, 1971.

Results and Discussion

A summary of the amounts of supplement consumed and performance of the cows is shown in Table 2. Intake of the four dry supplements was similar, with a range in daily intake of only 0.13 pounds per cow daily; intake of the natural 15 percent, urea and biuret supplements was almost identical. The percent of salt in the supplement-salt mixture necessary to limit intake differed somewhat among supplements. The natural 30 percent supplement was the most palatable and required the highest level of salt to limit intake, followed by the natural 15 percent supplement. The urea and biuret supplements were the least palatable, and the biuret supplement appeared to be slightly less palatable than the urea supplement since less salt was needed to limit intake of the biuret supplement.

The cows consumed more of the liquid 30 percent supplement than of the dry supplements, and the consumption of the molasses was excessively high even after a high level of aluminum sulfate was added to decrease palatability. To decrease the total intake of molasses the feeders were left empty for short periods of time.

The winter weight change of cows is shown in Table 2. The cows consuming the natural 30 percent dry supplement lost considerably less weight than the cows on the other treatments. The winter weight loss of cows consuming the "negative control" (15 percent protein) supplement was considerably greater than that of the group consuming the 30 percent all-natural protein supplement, indicating the definite need for supplemental protein above the amount supplied by the 15 percent protein supplement. The cows consuming supplements containing urea and biuret lost only slightly less weight than the cows on the 15 percent protein supplement indicating that the utilization of NPN was low. In this trial the problem of cattle adapting to biuret may not have been serious as the weight loss for the biuret cattle was not significantly different from that of the other groups during the first 28 days of the trial.

The weight loss of the cows on the liquid supplement was considerably greater than that of cows fed the all-natural 30 percent protein supplement and similar to but slightly greater than that of cows fed the all-natural 15 percent, urea and biuret supplements. This suggests that the utilization of urea nitrogen in the liquid supplement was approximately one-half that of the natural protein.

A comparison between liquid supplement and molasses was of questionable value, as an indicator of degree of utilization of urea in the liquid supplement, since intake of molasses was double that of liquid supplement. The performance of cows on molasses certainly demonstrated that the high levels of energy will not compensate for a large deficiency of protein.

The final condition scores of the cows followed the same general pattern as weight loss, and provided further support to the conclusions previously discussed.

Table 3 shows the weaning weight of calves and the rebreeding performance of the cows. The cows wintered on biuret weaned the heaviest calves and the cows wintered on the natural 15 percent protein supplement weaned the lightest calves; weaning weights of calves in the other groups were very similar. However, it is doubtful that weaning weights in this experiment were as accurate a reflection of winter supplement treatments as cow weights. Due to management considerations unrelated to this experiment, it was necessary to terminate the supplement comparisons February 27, after which time all cows received the same 30 percent natural protein supplement for almost two months. This would tend to

Table 3. Performance of Calves Born During Winter and Fertility of Cows Wintered on Various Range Supplements

Lot Treatment Crude Protein, %	1 Natural 30	2 Natural 15	3 Urea 30	4 Biuret 30	5 Liquid 30	6 Molasses 5
No. of cows calved[1]	10	10	9	9	9	9
Calving date (day of yr)	215	216	213	226	199	210
Birth wt. (lb.)[2]	80	76	82	73	79	78
Weaning wt. (lb.)[3]	540	521	542	551	548	542
No. cows rebred[4]	10	9	9	9	9	8

[1] Includes cows which calved during calving season. Some calved after the wintering trials.
[2] Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.
[3] Weaning weight adjusted to 205-day, steer, mature cow basis.
[4] All cows which failed to rebreed were exposed to bull at least 60 days post-partum.

mask differences due to previous supplementation, particularly since 36 percent of the calves were born after the supplement comparisons were terminated. For the same reason, it is doubtful that birth weights and rebreeding performance were greatly influenced by the supplement treatments.

At the same time, it is apparent that no winter supplement treatment adversly affected the future performance of the cows during the spring and summer. Cows which had lost more winter weight and were in thinner condition were able to compensate after wintering treatments had ended. This again was probably related to the short duration of the experiment.

Conclusions

The results of this experiment show that methods to improve the utilization of NPN on low quality dry winter range forage are urgently needed so that higher levels of NPN can be fed satisfactorially to range cows. Weight changes of cows indicated that utilization of NPN in all supplements was low.

It was again demonstrated in this experiment that salt can be effectively used to control the intake of dry self-fed supplements at a desired level.

The Performance Of Three- And Four-Year-Old Angus X Holstein Crossbred Cows Under Range Conditions

Robert Totusek, W. E. Sharp and Ivan Rush

Story in Brief

A winter supplementation level of 3.55 lb. (41 and 30 percent protein) per cow daily for 3-and-4-year-old Angus x Holstein crossbred cows on dry native grass was adequate to support good weaning weights (466 and 514 lb. at 205 days). Rebreeding performance was also considered good; the failure of 8.6 percent of the cows to rebreed was largely due to the fact that the breeding season was 2 months earlier than the previous year.

Introduction

There is much interest among cow-calf operators in increasing milk production of brood cows to raise weaning weights. Selection for heavy weaning weights automatically results in selection for increased milk production, but a much more rapid method of increasing milk production is the introduction of dairy breeding into a brood cow herd. It is recognized that a higher level of supplementation is necessary to support a higher level of milk production. Information on the performance of part-dairy brood cows under range conditions, and levels of necessary supplementation, is needed as a basis for determining the feasability of infusing dairy breeding.

The performance of a group of 2-year-old Angus x Holstein crossbred females was reported in the 1970 Animal Science Research Report (see Miscellaneous Publication 84, pp. 14-23). The Angus x Holstein crossbreds, compared to Angus females of similar age, had a higher calving percent and weaned a higher percent calf crop, calved earlier, produced more milk and weaned heavier calves (44 and 76 pounds for steers and heifers, respectively). However, only 13 percent of the Angus x Holstein crossbreds and 44 percent of the Angus females rebred. The level of supplementation was apparently too low for all cattle, but the higher milking crossbreds were much more susceptible to the adverse nutritional environment than the Angus.

The Angus x Holstein crossberds (39 head) were moved to a new location at the Lake Carl Blackwell Range in the fall of 1970 before calving in the spring of 1971 as 4-year-olds; their performance as 4-year-olds is reported here. In addition, the performance of a group of 3-year-old Angus x Holstein crossbreds (25 head) is also reported.

Procedure

The Angus x Holstein crossbred cows had been exposed to Angus bulls during May 1 to July 31 of 1970. Twenty-one of 25 and 37 of 39 were pregnant as 3- and 4-year-olds, respectively.

All cows were maintained on tallgrass native range yearlong. Prairie hay was fed only when the grass was covered by snow.

After weaning their calves as 2- and 3-year-olds in the fall of 1970, 21 of the cows were extremely thin. These cows were separated and fed 4 lb. of cottonseed meal per head daily during November and December; during this period the fatter cows were fed 2.2 lb. cottonseed meal per head daily. On January 1 all cows were again combined into one group and fed an average of 3.8 lb. of supplement (cottonseed pellets or a 30 percent natural-protein pellet) until April 20. The average supplement intake of all bred cows from November 5, 1970 to April 20, 1971 (164 days) was 3.55 lb. daily (Table 1).

Cows were pasture mated to Hereford bulls March 1 to May 26, 1971. Calves were weaned September 22, 1971.

Milk production estimates were obtained in May, June, July and September by weighing calves before and after nursing after two consecutive 12-hour periods during which cows and calves were separated.

Results and Discussion

Performance of the cows is summarized in Table 1. All six cows open initially conceived. Of the bred cows, the 4-year-olds calved 12 days earlier and produced calves eight pounds heavier at birth than the 3-year-olds. In addition, the 4-year-olds produced heavier calves at weaning, a 108 pound advantage for the steers and 56 pounds for the heifers. The average actual weaning weight of all calves was 527 and 445 pounds for the 4- and 3-year-old cows, respectively. Part of this advantage for the 4-year-olds was due to the older age of their calves, but even on a 205-day adjusted basis the 4-year-old cows had more advantage than normally expected due to a 1-year difference in age.

The weaning weights observed for the Angus x Holstein crossbred cows were considerably above those previously produced by straightbred cows of comparable ages on the same range; 3- and 4-year-old Angus and

Table 1. The Performance of Three- and Four-Year-Old Angus x Holstein Crossbred Range Cows

		3-year-old cows		4-year-old cows
Cows open initially				
No.		4		2
Daily supplement[1], lb.		3.45		3.45
No. conceiving		4		2
Cows pregnant initially				
No. cows		21		37
Daily supplement[1], lb.		3.55		3.55
Calving date		Mar. 6		Feb. 22
Birth wt.[2], lb.		71		79
No. calves weaned		21		35
Weaning wt., lb.				
Actual				
Steers	(189)[3]	436	(209)	544
Heifers	(199)	452	(213)	508
Total	(195)	445	(211)	527
Adjusted, 205-day basis				
Steers		467		535
Heifers		464		493
Total		466		514
Daily milk yield, lb.		13.2		14.0
No. cows open				
Total		6		3
Less than 60 days postpartum		4		0

[1] From 11-5-70 to 1-7-71 cottonseed pellets was fed, from 1-8-71 to 4-20-71 a 30% protein supplement was fed.
[2] Adjusted to bull equivalent by multiplying heifer weight by 1.048.
[3] Age in days at weaning.

Hereford cows have normally produced calves in the 400 to 435 pounds weight range, or approximately 450 pounds on a 205-day, steer, mature cow basis. The weaning weight of calves from the Angus x Holstein crossbreds in this study adjusted to the same basis was 530 and 560 pounds for the 3- and 4-year-olds, respectively. It is apparent that these particular half-dairy females are rather productive in terms of weaning weight of their calves.

The difference in estimated daily milk yield (Table 1), although in favor of the 4-year-old cows, was very small. The reason for the lack of a large difference in milk yield between 3- and 4-year-olds consistent with a large difference in weaning weight is not known.

It is interesting to compare the 205-day weaning weight of calves from the same cows at 2 and 4 years of age. Steer calves weighed 430 and 535 and heifer calves 320 and 493 pounds from the same cows at 2 and 4 years of age, respectively. These increases of 105 and 73 pounds from 2 to 4 years of age are somewhat larger than the 10 percent increase often observed with straight beef cows.

A total of six 3-year-olds and three 4-year-olds failed to rebreed. However, it should be pointed out that in order to move to an earlier calving season bulls were placed with the cows and removed 2 months earlier than the previous year. Consequently some cows were as little as 20 days postpartum when the breeding season ended and had little opportunity to rebreed. Of all cows which were at least 60 days postpartum, only two 3-year-olds and three 4-year-olds, a total of five of 58 cows, failed to rebreed. The percentage of open cows on this basis, 8.6 percent, is only slightly above the 3 to 5 percent open cows often observed in well managed beef herds.

Weights and condition scores are summarized in Table 2. The 4-year-olds lost considerably more weight than the 3-year-olds, probably because of earlier calving and higher milk production (as indicated by the weaning weight of the calves). Weight losses for both groups were within a range conducive to rebreeding, based on previous observations with straight beef females. Both groups showed some decrease in condition score during the year and failed to increase as much in condition score during the summer as desirable, probably due to their level of milk production.

The 3.55 pounds average daily supplement fed to the cows at 4 years of age can be compared to 2.0 pounds fed to the same cows at 2 years of age (when rebreeding performance was very poor) and the 2.5 pounds normally fed to spring calving beef cows of comparable age on the same range.

Table 2. Weights and Condition Scores of Three- and Four-Year-Old Angus x Holstein Cows

	3-Year-Old Cows	4-Year-Old Cows
Weight, lb.		
Initial, 9-29-70	864	1076
Pre-calving, 1-30-71	975	1181
End of winter, 4-16-71	822	943
Final, 9-21-71	935	1073
Weight change, lb.		
Pre-calving	+111	+105
Post-calving	—153	—238
Total winter	—23	—133
Summer	+94	+130
Total year	+71	—3
Condition score		
Initial, 9-29-70	3.6	5.1
End of winter, 4-16-71	2.9	3.0
Final, 9-21-71	3.3	3.6

Further Studies on Adaptation and Loss of Adaptation of Rumen Microorganisms to Biuret as a Nitrogen Source Fed with Low Quality Roughages

R. R. Johnson and E. T. Clemens

Story in Brief

The utilization of biuret as a nitrogen source for ruminants consuming low quality roughage is continuing to be studied. This years results suggest that the length of time required for adaptation to biuret by rumen microorganisms on roughage rations is directly related to the level of natural protein in the rations, that is, the more natural protein present, the longer the time required for adaptation. Furthermore, removal of the biuret from the ration caused an almost immediate loss of biuret hydrolyzing ability by rumen contents. In one growth trial with steers, biuret appeared to be utilized only partially as well as cottonseed meal.

Introduction

The search continues for lower cost nitrogen supplements that can be substituted for natural protein in protein supplements provided for grazing cattle and sheep. Recent studies in our department (Misc. Pub. No. 85, 1971) have shown that biuret will provide a less toxic, more slowly released form of nitrogen than urea, but considerable time is required for the rumen microorganisms to acquire the ability to break the biuret down to ammonia which is the useful form of nitrogen. For example, in the 1971 report, "biuretolytic" activity was not evident until after 42 days of supplementation with biuret. This years studies were designed to further investigate this time required for adaptation as well at the loss of adaptation after biuret is removed from the ration.

Materials and Methods

Trial 1. The rations shown in Table 1 were fed to rumen fistulated sheep for a period of 91 days. The objective was to compare the development of biuretolytic activity (ability to utilize biuret) when sheep received various combinations of biuret with natural protein, starch and urea.

Apparent digestibilities of ration components were determined during three different 7 day periods beginning at day 7, 42 and 84 of supplementation. The ability of the rumen microorganisms to hydrolyze biuret to ammonia was determined on days 6, 20, 42, 62 and 83 after beginning supplementation. This was accomplished by incubating a biuret solution with whole rumen contents in the laboratory and measuring disappearance of biuret. The data reported is percent disappearance of the original biuret in the flask.

Trial 2. Three fistulated dairy steers were fed prairie hay for 20 days during which time the level of biuretolytic activity in their rumen contents was determined. The biuret supplement shown in Table 2 was then fed to all three steers. Biuretolytic activity was determined on days 7, 16, 30, 44, 60 and 75 after the start of biuret feeding.

Two deadaptation trials were conducted with these steers. In the first, the adapted animals were returned to the cottonseed meal supplement and biuretolytic activity was determined on days 1, 2, 4, 7 and 10 after removal of biuret. They were then readapted to biuret. After readapting, the biuret supplement was again removed but no other supplement was given during the deadaptation study to determine the effect of

Table 1. Composition of Supplements and Feed Offerings—Trial 1

Ingredient	Supplement[1] composition, %				
	1 CSM	2 B+LS	3 CSM+HS	4 CSM+B	5 B+U
Cottonseed meal	89.3	–	42.4	37.7	–
Corn starch	–	75.4	52.2	37.7	75.8
Biuret, pure	–	15.4	–	15.4	12.3
Urea, 281	–	–	–	–	2.7
Limestone	3.6	3.1	1.8	3.1	3.1
Dical, phos.	3.6	3.1	1.8	3.1	3.1
T.M. salt	3.6	3.1	1.8	3.1	3.1
Vit. A & D	+	+	+	+	+
Daily ration, gm					
Chopped prairie hay	500	500	500	500	500
Supplement	170	170	340	170	170

[1] Abbreviations refer to CSM-cottonseed meal; B-biuret, LS-low starch, HS-high starch; U-urea.

Table 2. Composition of Supplements Fed to Fistulated Steers in Trial 2

Ingredient	Grams in mixture	
	Control supplement	Biuret supplement
Cottonseed meal	10,000	–
Corn starch	–	9800
Biuret	–	2000
Limestone	400	400
Dicalcium phosphate	400	400
T.M. salt	400	400
Vit A (30,000 I.U./gm)	2	2
	11,202	13002
Daily Ration		
Hay, prairie	7000 gm	7000 gm
Supplement	1700 gm	1700 gm
N obtained from supplement	95 gm	93 gm

the presence or absence of other nitrogen sources on the rate of loss of adaptation.

Trial 3. Twenty "black baldy" steers were alloted by weight to 4 lots and fed the rations shown in Table 3 free choice. These were designed as high roughage rations to support wintering type gains but feed consumption far exceeding expectations, as will be discussed later. Shrunk weights were taken before and after the 96 day feeding period.

Results and Discussion

Trial 1. Digestibility coefficients for the three periods of testing are shown in Table 4. Except for ration 3, there was a general increase in digestibility of dry matter and organic matter as the trial progressed. The reasons for this are not obvious but the most likely explanation would be

Table 3. Composition of Rations for Steers, Trial 3

Ingredient	Composition (%, as is basis)			
	1	2	3	4
Cottonseed hulls	70.2	70.2	70.1	70.1
Cottonseed meal	15.0	7.0	–	8.0
Ground corn	11.1	18.8	24.1	16.9
Molasses	2.0	2.0	2.0	2.0
Biuret	–	–	1.8	1.1
Limestone	0.5	0.3	0.3	0.4
Dicalcium phosphate	0.5	1.0	1.0	0.8
Sodium sulfate	0.1	0.1	0.1	0.1
T.M. salt	0.6	0.6	0.6	0.6
Vitamin A (30,000 I.U./gm)	5 gm/100 lb	5 gm/100 lb	5 gm/100 lb	5gm/100 lb

Table 4. Coefficients of Digestibility for Rations in Trial 1

Ration	Period[2]	DMD	OMD	ADFD	N-dig
		Digestibility coefficients[1]			
		%	%	%	%
1 CSM	1	53.8[a]	55.6[a]	46.1[a]	60.6[a]
	2	57.2[ab]	59.7[ab]	51.2[ab]	64.2[ab]
	3	68.7[b]	70.9[b]	63.7[b]	76.1[b]
2 B + LS	1	50.2[x]	51.7[xa]	45.5[a]	65.8[x]
	2	57.4[xy]	60.2[xyb]	49.1[a]	68.4[xy]
	3	62.3[y]	65.2[y]	51.8[a]	74.7[y]
3 CSM + HS	1	61.5[a]	63.2[a]	41.4[a]	60.6[a]
	2	62.0[a]	64.1[a]	53.9[b]	60.1[a]
	3	62.0[a]	61.4[a]	45.2[ab]	51.3[b]
4 CSM + B	1	48.7[a]	50.9[a]	34.8[a]	63.2[a]
	2	57.6[a]	60.4[a]	49.8[a]	76.3[a]
	3	66.2[b]	68.5[a]	57.6[a]	73.9[a]
5 B + U	1	48.0[a]	49.7[a]	51.4[a]	69.9[ab]
	2	61.4[b]	63.5[b]	52.6[a]	72.9[b]
	3	57.1[ab]	59.8[ab]	45.5[a]	62.5[a]

[1] DMD, OMD, ADFD refer to dry matter digestibility, organic matter digestibility, acid detergent fiber digestibility, RESP.

[2] Periods refer to 7 day collection periods starting with (1) day 7, (2) day 42 and (3) day 84 of supplemental feeding.

A, B
$P < .05$—Between Periods
X, Y
$P \leq .01$—Between Periods

that of a change in the quality of hay component in the ration. Although the bales of hay were taken from one lot, quality of prairie hay can vary considerably between bales. Statistically significant increases in nitrogen digestibility with time on feed were noted for the cottonseed meal, the biuret and a non-significant increase was noted for the CSM + biuret ration.

Nitrogen digestibility for the biuret plus urea ration increased in period 2 but decreased again in period 3. It is difficult to associate these changes directly with the ration supplement since the quality of hay may have been variable. However, the increases in nitrogen digestibility of the biuret rations agrees with previous observations and would obviously correlate with possible adaptation phenomena.

The biuretolytic activity of the rumen contents from the lambs fed these rations is illustrated in Table 5. There was no biuretolytic activity apparent at anytime in the animals fed rations 1 and 3 (no biuret in rations). On the other hand, biuretolytic activity did appear in all animals fed biuret but in somewhat of an erratic fashion. Rumen contents from animals on ration 2 showed low activity by 20 days (32 percent in 24

Table 5. Biuret Disappearance During Biuretolytic Tests—Trial 1

Period	Ration	1 CSM		2 B+LS		3 CSM+HS		4 CSM+B		5 B+U	
	Time, hrs[1]	8	24	8	24	8	24	8	24	8	24
		%		%		%		%		%	
1 (6)[2]		1.1	7.5	1.2	8.9	0	—0.6	2.0	9.0	2.6	8.6
2 (20)		0.4	3.4	6.2	31.5	—2.6	—2.6	2.1	11.2	2.2	9.2
3 (42)		—1.8	—1.8	6.2	24.1	—0.9	—2.6	10.3	32.9	12.8	72.6
4 (62)		—1.0	0.5	1.6	22.6	—3.0	—3.0	3.6	34.8	0.0	13.7
5 (83)		—0.4	0	7.4	16.0	—7.3	—6.7	8.5	55.9	—2.3	12.7

[1] Hours after initiation of in vitro biuretolytic fermentation.
[2] Days after start of supplemental feeding.

hrs) but never increased beyond that level. The activity in contents from ration 4 fed animals increased steadily from 42 to 83 days on feed. With ration 5, a high activity was noted on day 42 but this disappeared by 62 days and did not reappear. As will be seen later, this may have been due to accidental removal of biuret from the ration for a few days which causes an immediate loss of activity.

Although biuretolytic activity was not as high in this study as noted in last years work, the results suggest that development of the activity is more rapid if there are no other sources of nitrogen such as cottonseed meal or urea. This agrees with results by other workers.

Trial 2. The biuretolytic activity of the rumen contents from the fistulated steers in this trial are shown in Figure 1. The points on this curve represent averages of the three animals. On days 7 and 16 there was practically no biuretolytic activity observed. By day 30, however, maximum biuretolytic activity was developed with no further increases up to 75 days. This is more rapid than observed with the lambs in last years tests. Again, however, this was with a prairie hay with 4-5 percent crude protein while last years study was conducted with a bermuda grass hay with 8-9 percent protein. The presence of natural protein is known to delay development of biuretolytic activity.

We were interested in how rapidly the biuretolytic activity could be lost if biuret was removed from the ration. Figure 2 illustrates these results when the biuret supplement was replaced with the cottonseed meal supplement. Biuretolytic activity decreased markedly by day 1 and completely by day 4 after the switchover. Since considerable natural protein was present (cottonseed meal) it was decided to repeat this test using no protein supplement. The steers were readapted to the biuret supplement and then this supplement was removed without any replacement. These results are shown in Figure 3. Again most of the biuretolytic activity was lost after 2 days and all was lost by 4 days after removal.

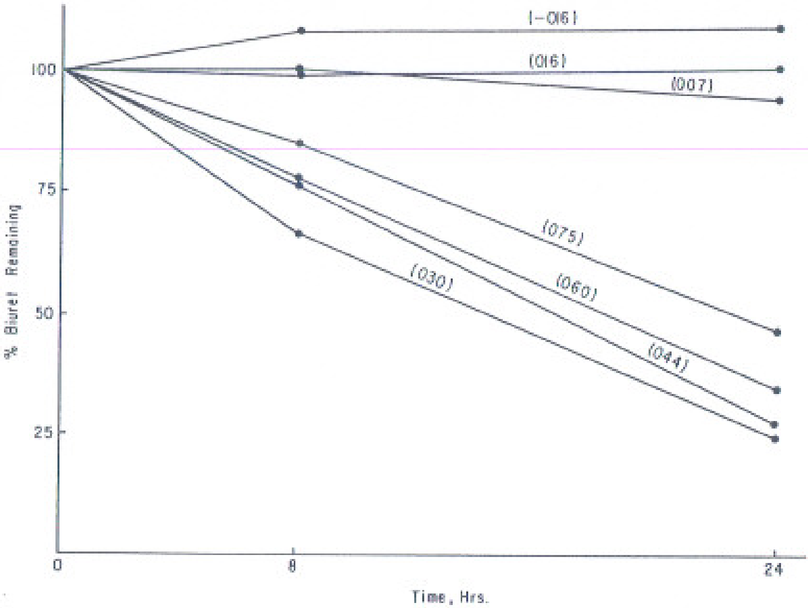

Figure 1. Biuretolytic activity of rumen contents from seers being fed a biuret supplement with prairie hay. Numbers refer to days before (—) or after (+) start of biuret supplement feeding.

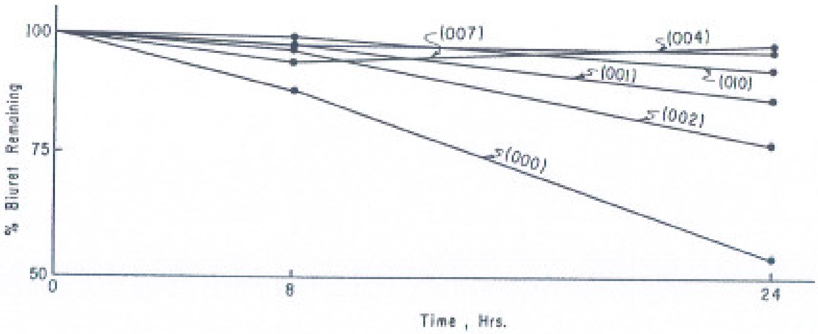

Figure 2. Biuretolytic activity of rumen contents from steers on various days following removal of biuret from the supplement (CSM supplement replaced biuret supplement).

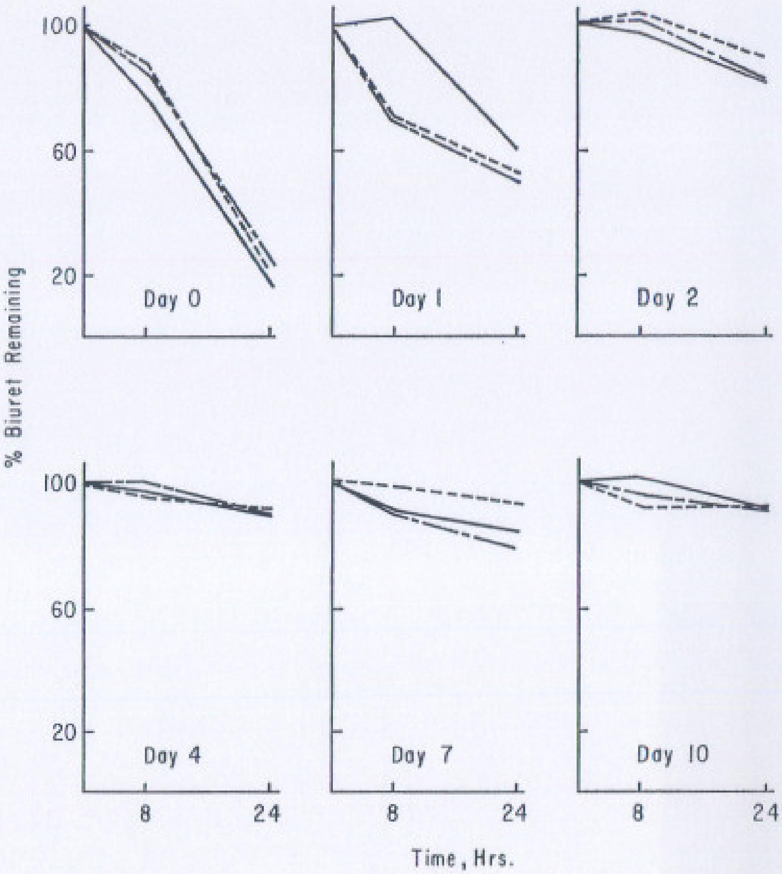

Figure 3. Biuretolytic activity of rumen contents of steers following second removal of biuret from the supplement (no other supplement provided).

These deadaptation results are significant from the standpoint that many beef cows are supplemented on alternate days or even only once or twice a week. This suggests that biuret adaptation might be difficult to maintain under these circumstances. This problem is being studied further at this time.

Trial 3. The steer growth trial was designed to stimulate a wintering situation in terms of ration and predicted gains. As such, the lot receiving one half the normal level of protein (ration 2 in Table 3) was a negative control utilized to estimate the extent of utilization of the test nitrogen sources. Table 6 presents the performance data for these steers. It is

Table 6. Performance of Steers on High Roughage Rations in Wintering Trial 3

Item[1]	1 CSM	2 ½ CSM	3 B	4 B+CSM
No. Animals	5	5	5	5
Days on feed	96	96	96	96
Total gain, lb.	332	256	290	275
Ave. daily gain, lb.	3.45	2.67	3.02	2.87
Ave. daily feed, lb., as is,	31.65	26.62	32.01	31.60
Feed per lb. gain, lb.	9.16	9.98	10.45	11.02

[1] CSM=cottonseed meal, B=biuret.

immediately obvious that the performance far exceeded predictions in that the average gain for all lots was over 2 lbs. per head per day. This is presumably due to the very high feed consumption exhibited by these steers, actually exceeding 4 percent of their body weight. Daily gains were highest for the CSM lot followed by the biuret lot and the CSM + biuret lot. The negative control gained at the lowest rate, but they also ate much less feed, typical in a protein deficiency situation. Their feed efficiency was second highest.

The steers on the biuret ration, lot 3, gained faster than the negative control but certainly less than the ones on CSM (lot 1). Furthermore, their feed efficiency was not as good since they ate as much feed as the CSM animals. Thus it is difficult to determine whether the biuret was well utilized or not. Looking at lot 4 where the feed consumption was still about the same, the average daily gain was slightly less than for lot 3 and the feed efficiency was the poorest of the four rations. Ration 4 contained the same quantity of CSM as ration 2, the negative control, plus half the amount of biuret fed to lot 3. Based on the feed consumption data plus the gains, it appears biuret did have an effect on rumen activity and was partially utilized but not as well as cottonseed meal.

Conclusions

Biuret adaptation is a slow process, the time for which can be influenced by the level of natural protein in the ration. The ability to hydrolyze and utilize biuret is quickly lost when biuret is removed from the ration. This may have important management implications. Biuret has been shown to be partially utilized in a growth study with steers but further tests are needed.

Digestibility of Feedlot Waste

R. R. Johnson

Story in Brief

Because of the recent intense interest on the possibilities of recycling feedlot waste through ruminant animals as a means of disposing of this agricultural pollutant, two digestion trials were conducted this past year to determine the digestibility of typical feedlot waste. The feedlot wastes utilized were characterized by very high ash content varying from 35 to 44 percent. Most of this was a highly indigestible and insoluble form of ash resembling sand. The organic matter portion of the feedlot waste, however, consisted of between 20 and 30 percent crude protein and 25 to 43 percent fiber.

Three separate samples of feedlot wastes were included in digestion trials with sheep at levels of 25 and 40 percent. Digestibilities of the dry matter of the feedlot waste component varied from 35 to 50 percent. Digestibilities for organic matter varied from 42 to 56 percent and for crude protein they varied from 60 to 71 percent digestibility.

Introduction

Recently considerable interest has been shown in the search for systems for removal and possible utilization of feedlot wastes from large feedlot operations such as those in western Oklahoma. Laws and regulations governing the handling of feedlot wastes are becoming more restritive every year and it would appear that enforcement of the requirement for some system to handle this material might be mandatory before long. Scientists, therefore, have been looking for economic systems for utilizing the waste for other purposes. One of the proposed uses has been the recycling of the waste through other ruminant animals to utilize any additional nutritive value they might contain.

Previous work conducted with manure and animal wastes, collected from confinement operations in the east and pure samples of manure from animals such as dairy cows, have shown that there is considerable nutritive value remaining in the feces when they have been voided. However, most of these studies have not been conducted with the kind of feedlot wastes which are typical of Oklahoma feedlots. In the case of feedlots in the southern high plains, not only are the rations often different from those fed in other areas of the country but the systems for collecting, removal and storage of the feedlot wastes are considerably different. Therefore, this experiment was initiated to investigate the nutritive value of feedlot wastes as a component of rations for ruminant animals.

Materials and Methods

Three samples of feedlot wastes were obtained from typical feedlot operations. The first was a sample from the mound of material which has been collected at the Texas County Feedlot in Guymon, Oklahoma. The second and third samples were obtained from the Ark Valley Feedlot, Arkansas City, Kansas, one being a feedlot waste from a growing lot and the other from a finishing lot. These latter two were removed directly from the lots themselves.

The feedlot wastes were included in rations at the level of 25 and 40 percent as shown in Table 1. These were basically high roughage rations consisting of cottonseed hulls plus a small amount of alfalfa meal and the feedlot wastes were substituted for the cottonseed hulls. These rations were fed to sheep in digestion trials and apparent digestibilities of the ration components were determined by the usual techniques. Based on the digestibilities observed, the theoretical digestibility of the feedlot waste itself was calculated.

Results and Discussion

Table 2 presents a summary of the composition of the feedlot wastes utilized in these experiments. It will be observed, first of all, that they were extremely high in ash content varying from 35 to 43.5 percent. Investigation of the solubility and digestibility of the ash showed that these parameters were close to zero which suggested that the ash or mineral content was primarily due to collection of wind blown dust and sand with the feedlot wastes in addition to soil included at the time of remov-

Table 1. Composition of Rations Containing Feedlot Wastes

Ingredient	Percent on Air Dry Basis						
	1	2	3	4	5	6	7
Cottonseed hulls	81	56	41	56	41	56	41
Dried feedlot waste, No. 1[1]	–	25	40	–	–	–	–
No. 2	–	–	–	25	40	–	–
No. 3	–	–	–	–	–	25	40
Alfalfa meal, 17%	10	10	10	10	10	10	0
Soybean meal, 44%	8	8	8	8	8	8	0
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5
T. M. Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vit A	+	+	+	+	+	+	+

[1]No. 1. From Texas County Feedlot
No. 2. Ark Valley Feedlot, Growing Lot
No. 3. Ark Valley Feedlot, Finishing Lot

Table 2. Composition of Feedlot Wastes

Component	Percent Composition, D.M. Basis[4]		
	No. 1[1]	No. 2[2]	No. 3[3]
Ash	43.5	36.4	35.2
Crude protein	14.8 (26.2)	15.0 (23.6)	19.2 (29.6)
Ether extract	2.9 (5.1)	.	
Cell walls	24.4 (43.2)	24.7 (38.8)	21.6 (33.3)
Acid det fiber	24.4 (43.2)	22.1 (34.7)	17.3 (26.7)
Cellulose	15.8 (28.0)	18.8 (29.6)	17.7 (27.3)
Lignin	5.0 (8.8)		

[1] Texas County Feedlot
[2] Ark Valley Feedlot, Growing Lots
[3] Ark-Vally Feedlot, Finishing Lots
[4] Figures in parenthesis are on ash free basis

al from the lot. The crude protein content varied from 15 to 19 percent on an "as is" basis and if this were calculated on an ash free basis it would vary from 20 to 30 percent. Furthermore, the acid detergent fiber content when calculated on an ash free basis varied from 25 to 40 percent.

The digestibilities of these rations and their components are shown in Tables 3 and 4. It will be noted, first of all, that in spite of the high percentage of feedlot wastes in these rations, the palatability of the rations apparently was not affected since the feed intake was essentially the same for all rations. Of course, if intake is calculated on an ash free basis, the intakes would be better for the control rations. Using the digestibilities shown in Table 3 and 4 and the respective percentages of material in these rations, the theoretical digestibility of the feedlot waste components of the rations were calculated and are presented in Table 5.

Digestibility of the dry matter varied from 35 to 50 percent and the organic matter from 42 to 56 percent. These digestibilities are in roughly the same range as many low quality roughages and therefore suggest that the nutritive value of the feedlot waste organic matter may well be similar to that of low quality roughages. The digestibility of the crude protein was even higher varying from 60 to 71 percent which is considerably in excess of poor quality roughages. Thus, the digestible protein content of the feedlot wastes is quite high.

Further analyses are being made on these rations and the feces from the animals in the digestion trial to determine the true digestibility of the energy in the ration to confirm the results shown above. If these data are confirmed, this would mean that the feedlot wastes as measured here might well be utilizable as a component for maintenance type rations such as those consumed by beef cows during the winter periods. Whether this could be done economically in association with feedlot operations is another question and must be researched further. During the coming year, further studies will be conducted on the nutritive value of these feedlot wastes to include studies on the maintenance and growth of ruminants over long periods of time with rations containing various proportions of the feedlot wastes.

Table 3. Intake and Digestibilities of FLW Rations (No. 1)

Item	1	2	3
Intake, lb. per 100 lb. B. W.	2.78	2.90	2.86
Digestion coefficients			
Dry matter	53.5	50.8	46.2
Organic matter	53.7	53.8	51.5
Cellulose	48.0	48.5	40.4
Nitrogen	48.2	52.1	56.2
Ash	50.5	36.2	31.9

Table 4. Intake and Digestibility of FLW Rations (No. 2 & No. 3)

Item	1	4	5	6	7
Intake, lb. per 100 lb. B.W.	2.71	2.37	2.60	2.52	2.63
Digestion coefficients					
Dry matter	54.1	50.7	45.9	54.7	50.3
Organic matter	54.3	52.3	48.7	56.7	53.9
Cellulose	48.5	50.7	45.5	55.5	49.3
Nitrogen	49.6	51.6	54.0	55.0	57.2
Ash	51.2	41.4	34.8	41.2	33.4

Table 5. Calculated Theoretical Digestibilities of Feedlot Waste

	Apparent Digestibilities, %		
	No. 1	No. 2	No. 3
Dry matter	40	35	50
Organic matter	49	42	56
Crude protein	67	60	71

A Comparison In Feedlot Performance of Steers Allowed A Growing Period With Steers Placed on A Finishing Ration at Weaning

Lelan R. Lancaster, R. R. Frahm and Donald R. Gill

Story in Brief

A 194 day feeding trial involving 91 Angus steers was conducted at the Fort Reno Livestock Research Station to compare the performance of weaning calves placed directly on a finishing ration with that of steers allowed a growing period before being placed on a high concentrate finishing ration. One group was placed on a high roughage grower ration for the first 76 days of the trial before changing to a high concentrate finishing ration while the other group was placed directly on the high concentrate finishing ration at the time the calves were weaned.

The feeding trial was divided into two periods. The first consisted of 76 days where one group was on the grower ration and the second consisted of the remaining 118 days of the trial during which both groups were on the same finishing ration. Total weight, average daily gain, and change in wither height significantly favored the concentrate group at the end of the first period. Average daily gain during the last period was significantly higher for the steers that had been on the grower ration. However, average daily gain for the entire feeding trial as well as final weight was not significantly different. Over the entire feeding trial, the steers on the finishing ration required 0.57 pounds less feed per pound of gain than the steers on the grower ration. In general the carcass traits were similar for the two treatment groups, however, average fat thickness, carcass grade and marbling were significantly higher for the calves on the finishing ration. Total cost per pound of gain was 0.5 cents higher for the calves that initially began on the grower ration.

Introduction

Increasing per capita consumption of beef with an ever decreasing land mass for grazing has stimulated research concerning the effects of

In cooperation with Fort Reno Livestock Research Station, Agriculture Research Service, Animal Science Research Division, USDA.

placing weaning calves directly into the feedlot rather than allowing a growing phase prior to the finishing phase. The purpose of this study was to compare feedlot performance and carcass composition of calves placed directly on a finishing ration with those allowed a growth period prior to entering the finishing phase.

Materials and Methods

A 194-day feeding trial was conducted to compare feedlot performance of 205 day old calves placed directly on a high concentrate finishing ration with calves allowed a growing period of 76 days before being placed on the finishing ration. The 94 choice Angus steers initially allotted to this experiment were the progeny of 10 sires involved in a progeny test as part of the beef cattle breeding project. Half of the progeny from each sire were randomly allotted to each of the two treatment groups in such a way that the overall actual weaning weights were quite similar for the two treatments.

The steers were weaned at an average age of 205 days at the Lake Carl Blackwell range and were transported to the Fort Reno Livestock Research Station where they were immediately placed on test. Three animals died while on test (one on the grower ration and two on the finishing ration) and data from those were excluded from the analysis. The final analysis was completed on 45 calves on the grower ration and 46 calves on the finishing ration. The composition of the rations and supplements are presented in Tables 1 and 2, respectively. The rations were fed *ad lib* during the 194 day feeding trial. The steers were fed in two adjoining pens that opened to the south from a feeding barn.

The feeding trial was divided into two periods. The first consisted of 76 days during which one set of steers was fed the grower ration while the other set of steers was placed directly on a high concentrate finishing ration. The second period consisted of the remaining 118 days of the feeding trial. During the second period the steers originally on the grower ration were allowed an adjustment period of the first 21 days in which the milo level was gradually increased from 50 to 78 percent. From this point until the end of the trial both sets of steers were on the same finishing ration.

Twenty random steers from each treatment group was evaluated by the K^{40} counter at the OSU Live Animal Evaluation Center and subsequently slaughtered in the OSU Meat Laboratory. In addition to the normal carcass measurements, specific gravity was determined for the right side of each carcass. The balance of the steers were slaughtered at a commercial packing plant and only the normal carcass measurements were obtained.

Table 1. Composition of Rations

Ingredient	Cost/Cwt	Amount in Percent: Grower Ration	Amount in Percent: Finishing[1] Ration
Alfalfa Hay	$ 1.80	84	8
Dry Rolled Milo	2.30	5	78
Wheat Straw	1.00		4
Molasses	1.75	6	5
Supplement (No. 1)	3.70	5	
Supplement (No. 2)	4.74		5
	TOTAL	100	100

[1] The percentages reflect the finishing ration fed after an adjustment period of 26 days during which the milo level was gradually increased from 50 to 78 percent.

Table 2. Composition of Supplements[1]

Ingredient	Amount in Percent: Supplement 1	Amount in Percent: Supplement 2
Salt	8.000	8.000
Dicalcium Phosphate	6.000	
Calcium Carbonate		10.000
Stilbesterol, 2 g/lb.	0.625	0.625
Aureomycin, 10 g/lb.	1.250	1.250
Vitamin A[2]	0.625	0.625
Trace Minerals	0.500	0.500
Wheat Middlings	83.000	
Urea, 45% N		12.000
Soybean Oil Meal, 44% CP		67.000
TOTAL	100.000	100.000

[1] Both supplements were pelleted.
[2] Four million I.U. per lb.

Results and Discussion

The feedlot performance data from the two treatment groups are presented in Table 3. The initial weights were obtained on the steers immediately after being unloaded from the trucks at Fort Reno and prior to being placed in the feeding pens. They shrank 8.8 percent of their weaning weight going from Stillwater to Fort Reno. The slight difference in the initial weights of the two treatment groups was probably due to the initial allotment to treatment groups being based on weaning weights and the data on three steers that died being eliminated from the analysis.

Table 3. Feedlot Performance Data (194 Days)

Traits Measured	Grower Ration Steers	Finishing Ration Steers	Difference (Finishing-Grower)
Number of steers	45	46	
Initial weight, lbs.	435	430	—5
Final weight, first period, lbs.	603	646	43 **
Change in wither height, first period, in.	2.55	3.17	0.62**
ADG first period, lbs.	2.22	2.84	0.62**
Final feedlot weight, lbs.	982	980	—2
ADG last period, lbs.	3.21	2.83	— .38**
ADG total, lbs.	2.82	2.83	0.01
Lbs. feed/lb. gain, first period	6.74	5.52	—1.22[1]
Lbs. feed/lb. gain, last period	6.49	6.30	— .19[1]
Lbs. feed/lb. gain, total	6.57	6.00	— .57[1]

[1] Statistical tests of significance were not possible since feed efficiency was determined on a treatment group basis.
**Treatment means different at the 0.01 probability level.

As expected, total weight and average daily gain at the end of the first 76 days significantly favored the group of steers on the finishing ration. Also the steers on the finishing ration had a 1.22 lb. advantage in feed efficiency. This would appear to be a real difference, although it was not possible to make a statistical test of significance because feed efficiency was determined on a group rather than individual basis. Change in wither height during the first period was significantly greater for the steers on the finishing ration, indicating that structural growth occurred at a faster rate on the finishing ration than on the grower ration. Average daily gain for the last 118 days was significantly higher for the calves that were previously on the grower ration. It should be noted that although the finishing ration steers did not gain as rapidly as the grower ration steers during the final feedlot period, they were slightly more efficient in terms of pounds of feed required per pound of gain.

The most striking result of the feedlot performance was that average daily gain for the total feeding trial and final weight off test were not significantly different for the two treatments. Even though total feedlot gain was essentially the same for the two treatments, the group of steers on the finishing ration for the entire feedlot period was slightly more efficient in terms of pounds of feed required per pound of gain. The 1.22 lb. advantage in feed efficiency for the finishing ration steers during the first period and 0.19 lb. advantage during the last period resulted in a 0.57 lb. advantage over the total feeding trial.

In general the carcass traits were similar for the two treatment groups (Table 4). Although the final feedlot weight was essentially the same for the two groups the hot carcass weight was 12 lbs. heavier for the finishing

Table 4. Carcass Data

Traits Measured	Grower Ration Steers	Finishing Ration Steers	Difference (Finishing-Grower)
Number of steers	45	46	
Hot carcass weight, lbs.	589	601	12
Ribeye area, sq. in.	10.83	10.75	— .08
Kidney, heart and pelvic fat, %	2.87	3.02	0.15
Average fat covering, in.	0.73	0.85	0.12**
Carcass conformation[1]	11.78	11.91	0.13
Carcass grade[1]	9.36	10.02	0.66**
Marbling[2]	4.58	5.11	0.53**
Cutability[3]	49.25	48.53	— .72
Carcass length, in.	45.89	45.59	— .30
Carcass width, in.	14.82	14.92	0.10
Tenderometer[4]	17.18	17.34	0.16
K^{40} count, counts/min.[5]	14,049	14,066	17
Specific gravity[5]	1.048	1.045	— .003

[1] USDA carcass conformation and grades converted to the following numerical designations: high choice—12, avg. choice—11, low choice—10, high good—9.
[2] Marbling score equivalents: moderate—7, modest—6, small—5, slight—4.
[3] Estimated persentage boneless retail cuts from the round, loin rib and chuck of hot carcass weight.
[4] Smaller values indicates a more tender cut.
[5] Measurements obtained only on a random sample of 40 steers (20 from each treatment).
**Treatment means different at the 0.01 probability level.

ration steers. However, this difference was not statistically significant. The finishing ration resulted in a larger amount of fat as indicated by significantly more fat over the 12th rib and a higher marbling score. Consequently, the finishing ration steers received a significantly higher carcass grade. Although the steers on the finishing ration were somewhat fatter at the 12th rib, net K^{40} counts per minute and specific gravity did not indicate any significant difference in body composition.

An economic evaluation of these cattle is presented in Table 5. Cost per pound of gain was computed using feed costs as shown in Table 1 and a charge of 0.12 cents per head per day yardage fee. On this basis the cost per pound of gain was 0.5 of a cent per pound less for the finishing ration. Cost per pound of gain may seem comparably low but this was primarily due to the extremely high feed efficiency obtained by both groups of cattle.

Results from this study suggest that calves can be taken directly off the cows at an average age of 205 days and placed immediately into the feedlots on a finishing ration, and that these calves will grow and result in feedlot performance and carcass composition that is equivalent to and in some cases better than that obtained from cattle allowed a growing period before entering the feedlots. This study indicates that comparable performance from weaning to slaughter can be obtained on this kind of cattle by either system of management. The actual choice will be highly dependent upon the relative availability and cost of roughages and concentrates in a particular situation.

Table 5. Economic Evaluation of Feedlot Performance

Items	Cost/lb. of gain: Grower Ration	Cost/lb. of gain: Finishing Ration
Number of steers	45	46
Total lbs. gained	24,610	25,285
Ration costs	$ .143	$ .139
Yardage @12¢/head/day	.043	.042
Total cost	$ .186	$ .181

Effect of Milo Preparation on Energy Utilization by Feedlot Steers as Determined by Respiration Calorimetry and Comparative Slaughter

H. E. Kiesling, J. E. McCroskey and D. G. Wagner

Story in Brief

Eighteen Yearling Hereford steers were used to measure the energetic efficiency of feedlot rations containing dry rolled (DR) or reconstituted (38 percent moisture) rolled (RR) milo, and to compare respiration calorimetry and the comparative slaughter technique as methods for determining net energy of high concentrate feedlot rations. Net energy of the RR grain ration was significantly ($P<.01$) greater than the DR grain ration during the feedlot phase as determined by the comparative slaughter technique.

When determined by respiration calorimetry net energy tended to be greater for the RR grain ration but differences between the two rations were not statistically significant. A comparison of the two methods showed that net energy values for both rations were significantly ($P<.001$) greater when determined by respiration calorimetry than when determined by the slaughter technique.

Introduction

Due to the small size of milo grain it is necessary to process the grain in order to obtain satisfactory gain and feed efficiency by feedlot cattle. Various processing methods such as grinding, pelleting, rolling, popping, steam-flaking and reconstituting have been tried. Previous work at this station has shown that reconstituting milo greatly improves feed efficiency over dry processed milo without affecting rate of gain of feedlot cattle.

Early work in measuring efficiency of energy utilization was done with respiration calorimetry; however, due to the tedious and time consuming nature of this method most of the present day work in energy studies with cattle has been done using the comparative slaughter technique. Modern technology and high speed data processing have made respiration calorimetry more practicable. This study was undertaken to investigate the effect of reconstituting milo on the net energy value of high concentrate rations for feedlot cattle, and to compare respiration calorimetry and the comparative slaughter technique as methods for measuring energy utilization.

Materials and Methods

The two processing treatments studied were dry rolled and reconstituted rolled milo grain. Reconstituted grain containing about 38 percent moisture was prepared by soaking air-dry grain in water for 24 hours, after which the excess water was drained. This grain was stored in air-tight plastic bags for 20 days. Both the dry and reconstituted grains were rolled through a 12 x 18 inch roller mill prior to feeding. Other ingredients were combined into a premix which was added to the rolled grain so that both rations contained 84 percent milo on a dry matter basis as shown in Table 1.

Eighteen yearling Hereford steers weighing approximately 600 pounds were divided into three equal groups. One group was slaughtered at the start of the study and carcass specific gravity determined to estimate body composition of the experimental lots in order that net energy values of the two rations could be estimated by the comparative slaughter technique. The remaining animals were drenched with thiabendazole, im-

Table 1. Ingredient Composition of Rations

	(% of Ration DM)
Rolled milo	84.0
Dehydrated alfalfa meal pellets (17% CP)	4.93
Cottonseed hulls	4.93
Soybean meal (44% CP)	4.30
Urea (45% nitrogen)	0.64
Salt	0.60
Bonemeal	0.60
Vitamin A (1600 IU/lb. of ration)	
Chlortetracycline (5 mg/lb. of ration)	

planted with 24 mg of diethylstilbesterol and placed in pens equipped with individual feeding stalls.

The study consisted of a feedlot phase an dtwo total energy balance trials, one at the beginning of the feedlot phase (energy balance trial 1) and another at the end of the feedlot period (energy balance trial 2). Each energy balance trial consisted of an excreta collection period, a heat production phase with cattle on full feed, and a fasting heat production phase. Heat production of the animals was determined while the animals were in respiration chambers by measuring oxygen consumption, carbon dioxide and methane production, and urinary nitrogen excretion during two consecutive 24-hour periods. Fasting heat production was measured to estimate the maintenance energy requirement of each steer.

Upon completion of energy balance trial 1, the steers were placed in the feeding pens where they were fed ad libitum in individual stalls. The cattle were returned to the respiration chambers for a second energy balance trial at the completion of the feedlot phase. All animals were slaughtered immediately after energy balance trial 2 and carcass specific gravity was determined.

Feed, fecal and urine samples were analyzed for dry matter, protein, fiber and heat of combustion (energy) by standard laboratory procedures Net energy for maintenance plus gain (NEm+g) of each ration was determined during each total energy balance trial using respiration calorimetry and during the feedlot period using the comparative slaughter technique.

Results and Discussion

Feedlot performance for the two groups is shown in Table 2. One steer in the RR grain-fed group died due to bloat, which was not attributed to the milo processing treatment. During the feedlot period average daily dry matter intake was significantly ($P < .05$) less for the cattle on the RR grain rations. Although not statistically significant, feed efficiency was 8.25 percent greater for the RR grain-fed group. In addition, the RR grain ration had a significantly ($P < .01$) greater NEm+g than the DR grain ration when determined by the comparative slaughter technique. These results are in agreement with other reports in which reconstituted milo was compared with the dry form.

Results of the two total energy balance trials are shown in Table 3. Since feed intake was lower for cattle fed the RR grain ration, all comparisons were made on the basis of dry matter consumed. In both energy balance trials digestible energy was higher for the RR grain ration. Several reports have suggested that the benefit from reconstituting milo is due to increased digestibility of the grain. This study supports that suggestion. Net energy tended to be greater for the RR grain ration than for

Table 2. Effect of Milo Preparation on Feedlot Performance and Energetic Efficiency of Feedlot Steers Determined by the Comparative Slaughter Technique

Item	Dry rolled grain	Reconstituted rolled grain
Initial empty body wt. (lb.)	599	604
Final empty body wt. (lb.)	916	908
Avg. daily empty body wt. gain (lb.)	2.10	1.83
Avg. daily dry matter intake (lb.)	16.3	12.9*
Dry matter/lb. empty body wt. gain (lb.)	7.88	7.23
Avg. daily energy gain/lb. DM (kcal)	1.96	1.93
NEm+g (Mcal/100 lb. DM)	66.2	77.0**

* Means in the same row differ significantly ($P \leq .05$).
**Means in the same row differ significantly ($P \leq .01$).

Table 3. Effect of Milo Preparation on Energetic Efficiency of Feedlot Steers Determined by Respiration Calorimetry

	Balance trial 1		Balance trial 2	
	DR grain[1]	RR grain[2]	DR grain[1]	RR grain[2]
Steer wt. (lb.)	688	653	954	945
Daily feed (lb. DM)	13.4	9.1**	13.8	10.6**
Gross energy consumed (Mcal/day)	27.36	18.86**	27.8	21.36**
Digestible energy (Mcal/100 DM daily)	150.5	165.4**	147.3	154.9*
Metabolizable energy (Mcal/100 lb. DM daily)	121.8	129.0	117.0	126.6**
Net energy (Mcal/100 lb. DM daily)	90.3	97.3	86.2	87.3

[1] Dry rolled milo.
[2] Reconstituted rolled milo.
* Means in the same row within each balance trial differ significantly ($P \leq .05$).
**Means in the same row within each balance trial differ significantly ($P \leq .01$).

the DR grain ration in both balance trials but the differences were not statistically significant. The NEm+g values of both rations were lower in trial 2 than in trial 1 indicating that the net energy value of a feed decreases as the animal fattens.

A comparison of techniques for estimating NEm+g of the total ration is given in Table 4. The values for respiration calorimetry were obtained by pooling the data of the two energy balanced trials. Net energy values determined by respiration calorimetry were significantly ($P<.001$) higher (approximately 28 percent) than values determined by the comparative slaughter technique. These higher values appeared to be valid since the maintenance requirement of an animal would be less when confined to a respiration chamber due to less activity and environmental stress.

Results of this study indicate that efficiency of feed and energy utilization of milo grain can be increased approximately 16 percent by reconstituting the grain to approximately 38 percent moisture.

Table 4. Comparison of Respiration Calorimetry and the Comparative Slaughter Technique for Measuring NEm+g of Feedlot Rations

Item	Respiration[1] calorimetry	Slaughter technique
	(MCal NEmtg/100 lb. DM)	
Dry rolled grain ration	88.3	66.2***
Reconstituted, rolled grain ration	94.2	77.0***
Average	91.0	71.1***

[1] Data for trials 1 and 2 were pooled.
***Means in the same row differ significantly ($P< .001$).

Effect Of Physical Form Of Reconstituted Wheat During Storage On The Nutritive Value Of Wheat For Feedlot Cattle

Ryan Christiansen and Donald G. Wagner

Story in Brief

Four methods of processing wheat—dry rolled, ground-reconstituted, rolled-reconstituted and whole-reconstituted—were compared with dry rolled mile in 90 percent concentrate rations for finishing beef cattle. The wheat for the ground-reconstituted and rolled-reconstituted treatments was ground and rolled, respectively, before reconstituting. The wheat for the whole-reconstituted treatment was reconstituted and stored in the whole form and then rolled just prior to feeding. All reconstituted wheat was reconstituted to 30 percent moisture and then stored in air tight plastic bags for 21 days before feeding. Wheat made up 70 percent of the total ration in all wheat treatments on a 90 percent dry matter basis.

In the 137 day steer feeding trial, average daily feed intakes for the dry rolled milo, dry rolled wheat, ground-reconstituted wheat, rolled-reconstituted wheat and whole-reconstituted wheat treatments were 24.9, 21.7, 21.8, 22.2 and 23.7 lb., respectively, on a 90 percent D.M. basis. Average daily gains were 3.59, 3.28, 3.37, 3.46 and 3.97 lb. per day; the pounds of feed required per pound of gain were 6.94, 6.63, 6.46, 6.45 and 5.97; and the NE_g values of the processed grain were 99.4, 116.8, 108.1, 103.1 and 107.8 Mcal per 100 kg for the same treatments, respectively. The values for average daily feed intakes, gains, feed conversions and NE_g were not significantly ($P > .05$) different among treatments.

Introduction

Wheat prices have usually been too high in most years to permit extensive use of wheat as livestock feed. Therefore, considerably more research has been conducted in the past with corn and to a lesser extent with grain sorghum than with wheat as an energy source in high concentrate finishing rations. In recent years, however, wheat has become very competitively priced with other grains as an energy source in beef cattle feedlot rations.

Since wheat represents a major economic crop in Oklahoma, beef cattle feeders in this area have easy access to wheat for inclusion in cattle finishing rations. As a result, there has been much interest in different methods of processing wheat. This interest has been generated by research results showing that some processing techniques, such as reconstitution, have proven beneficial for substantially increasing the nutritive value of some grains, particularly milo, for feedlot cattle. To date, practically no research has been done to study the influence of reconstituted wheat fed in high concentrate rations to finishing beef cattle. The purpose of this experiment, therefore, was to compare different methods of reconstituting wheat with dry rolled wheat and dry rolled milo.

Materials and Methods

Choice feeder steers averaging 662 pounds were selected for use in this feeding experiment. The steers were gradually adapted to a 90 percent concentrate ration during a three week preliminary period. Following the preliminary period, twelve steers were selected at random as an initial slaughter sample to permit the determination of net energy values for the wheat and milo. The 50 remaining steers were blocked into two groups on the basis of weight and then randomly allotted within blocks to five treatments with five animals per pen, allowing ten animals per treatment. The treatments studied were as follows:

1) Dry rolled milo (DRM)
2) Dry rolled wheat (DRW)
3) Ground-reconstituted wheat (GRW)
4) Rolled-reconstituted wheat (RRW)
5) Whole-reconstituted wheat (WRW)

The steers were implanted with 36mg of stilbestrol at the beginning of the feeding trial.

The milo and wheat for the dry rolled treatments were rolled through a 12 x 18″ roller mill with a roller spacing of .003 inch. The wheat for all the reconstituted wheat treatments (GRW, RRW, and WRW) was reconstituted to 30 percent moisture, followed by storage in air tight plastic bags for 21 days prior to feeding. The wheat used was a hard red winter wheat. Temperature during storage of the reconstituted grain was a minimum of 70° F.

The ground-reconstituted wheat was obtained by grinding the wheat through an ⅛ inch hammermill screen prior to reconstitution and storage. The rolled-reconstituted wheat was rolled through the roller mill specified above prior to reconstitution and storage. The whole reconstituted wheat was reconstituted in the whole form and then rolled just prior to being fed. Thus, the physical form of the wheat during storage of the reconstituted grain was either ground, rolled or whole, respectively.

The compositions of the experimental rations are given in Table 1. The rations were all formulated to contain the composition indicated on a 90 percent D.M. basis with wheat making up 70 percent of the total ration on the wheat treatments. All rations were high concentrate rations containing 5 percent cottonseed hulls and 5 percent pelleted alfalfa meal. The milo included in the wheat rations was dry rolled. Feed was prepared and fed daily in quantities which permitted availability of feed until the next feeding. At two separate times during the feeding period rumen samples were obtained from each animal two hours after feeding. pH values were determined immediately, and a small amount was saved for VFA analyses.

Initial and final weights were taken after a 16 hour shrink off feed and water. Carcass specific gravities were determined on each animal at the conclusion of the feeding period to permit net energy-determinations for the feed using the comparative slaughter technique.

Results and Discussion

The proximate analysis and moisture composition data for the milo and wheat treatments are shown in Table 2. As indicated, the average moisture content of the dry rolled milo, dry rolled wheat, ground-reconstituted wheat, rolled-reconstituted wheat and whole-reconstituted wheat were 87.2, 89.2, 69.0, 69.1 and 69.4 percent respectively. Particle size and densities of the processed grains are shown in Table 3.

The feedlot performance data for feed intake, rate of gain and feed efficiency are given in Table 4. Average daily feed intakes for the dry rolled milo, dry rolled wheat, ground-reconstituted wheat, rolled-reconstituted wheat and whole-reconstituted wheat treatments were 24.9, 21.7, 21.8, 22.2 and 23.7 lb., respectively, on a 90 percent D.M. basis. Average daily gains were 3.59, 3.28, 3.37, 3.46 and 3.97 lb., and the pounds of

Table 1. Ration Composition[1]

Ingredient	Dry Rolled Milo Treatment	Wheat Treatments
	%	%
Wheat	--	70.0
Milo	84.0	14.0
Premix[2]	16.0	16.0

[1] Formulated on a 90% D.M. basis.
[2] Contained cottonseed hulls, ground alfalfa hay, soybean meal, urea, minerals, antibiotics and Vitamin A.

Table 2. Proximate Analysis of Milo and Wheat

Feed	Dry Matter	Crude Protein[1]	Ash[1]	Ether Extract[1]	CHO[1,2]
		percent			
Dry Rolled Milo	87.2	10.20[3]	1.40	2.90	85.00
Wheat		14.15[4]	2.08	1.33	82.45
Dry Rolled	89.2				
Ground Recon.	69.0				
Rolled Recon.	69.1				
Whole Recon.	69.4				

[1] Values expressed on 100% D.M. basis.
[2] 100 − (Sum of figures for crude protein, ash and ether extract).
[3] 6.25 x percent Nitrogen = percent crude protein.
[4] 5.71 x percent Nitrogen = percent crude protein.

Table 3. Particle Size and Density of Milo and Processed Wheat

	Screen Size							
	4mm	2mm	1mm	500 micron	250 micron	125 micron	Through 125 micron	Wt. per Bu.
	% Retained						Through	lb.
DRM	0.0	6.4	67.1	12.9	7.8	1.8	4.0	38.0
DRW	0.1	39.9	45.0	8.6	2.6	1.5	2.4	35.5
GRW	0.8	59.6	36.6	1.9	0.9	0.2	0.1	28.5
RRW	7.6	79.0	12.6	0.5	0.2	0.1	0.0	26.4
WRW	25.0	69.1	4.1	1.6	0.2	0.0	0.0	25.7

feed required per pound of gain were 6.94, 6.63, 6.46, 6.45 and 5.97 for the same treatments respectively. Although mean values for rate of gain and feed efficiency appeared to favor the whole-reconstituted wheat treatment, the differences were not significant ($P>.05$). The slightly better feed conversions obtained on the whole-reconstituted wheat treatment can likely be explained by somewhat greater intakes and gains in that increased intakes on any given ration and/or increased gains are usually reflected in improved feed conversions in feedlot cattle due to dilution of the maintenance requirement.

The net energy values for NE_{m+g} of the total ration and for NE_{m+g}, NE_m and NE_g of the grain are shown in Table 5. The NE_{m+g}, NE_m and NE_g of the grain in the wheat treatments refers only to the wheat, which made up 70 percent of the total ration. There were no significant differences ($P>.05$) between treatments for any of the net energy values. Reconstitution did not appear to measurably increase the nutritive value of the wheat for feedlot cattle in this experiment as is normally true for sorghum grain. However, palatability of the whole reconstituted wheat

Table 4. Feedlot Performance (137 Days)

	Dry Rolled Milo	Dry Rolled Wheat	Ground Reconstituted Wheat	Rolled Reconstituted Wheat	Whole Reconstituted Wheat
No. of Steers	10	10	10	10	10
Initial weight, lb.	658	665	657	668	663
Final weight, lb.	1149	1113	1119	1142	1206
Daily feed, lb.[1,2]	24.9	21.7	21.8	22.2	23.72
Daily gain, lb.[2]	3.59	3.28	3.37	3.46	3.97
Feed/lb. gain, lb.[1,2]	6.94	6.63	6.46	6.45	5.97

[1] Expressed on a 90% D.M. basis.
[2] None of the values for feed intake, gain or feed per lb. of gain were significantly different at .05 level of probability.

Table 5. Net Energy Values

	Dry Rolled Milo	Dry Rolled Wheat	Ground Reconstituted Wheat	Rolled Reconstituted Wheat	Whole Reconstituted Wheat
			Mcal/100 kg		
NE_{m+g} of Total Ration	129.0	144.9	139.6	135.9	137.5
NE_{m+g} of Grain	135.0	156.7	149.0	143.8	146.1
NE_m of Grain	149.1	175.2	162.1	154.6	161.7
NE_g of Grain	99.4	116.8	108.1	103.1	107.8

may have been slightly better as indicated by the somewhat higher feed intakes. In general the relatively low net energy values observed in this experiment supports previous research at Oklahoma State suggesting that heavy, fast gaining cattle may show relatively lower net energy values for the feed they are consuming than lighter, slower gaining cattle.

Carcass characteristics, percent cutability and dressing percentage for the animals in the experiment are shown in Table 6. There were no significant differences ($P>.05$) between treatments for any of the carcass traits measured.

Mean pH values for the dry rolled milo, dry rolled wheat, ground-reconstituted wheat, rolled-reconstituted wheat and the whole-reconstituted wheat were 5.7, 5.4, 5.3, 5.5 and 5.9 for the first collection and 5.6, 5.4, 5.8, 5.6 and 5.6 for the second collection, respectively. Although it is known that high levels of wheat may be prone to inducing a lower rumen pH under some circumstances, no significant differences ($P>.05$) existed between treatments in this experiment. VFA productions are also being determined on the rations.

In brief, this experiment would suggest that wheat can be successfully fed in high concentrate rations and that reconstitution does not produce the same degree of increase in the nutritive value of wheat for feedlot cattle as does reconstitution of sorghum grain.

Table 6. Slaughter and Carcass Information

	Dry Rolled Milo	Dry Rolled Wheat	Ground Re-constituted Wheat	Rolled Re-constituted Wheat	Whole Re-constituted Wheat
Dressing %[1]	59.2	60.0	59.3	59.8	58.7
Carcass grade[2]	9.4	9.4	10.5	9.1	9.7
Ribeye area, sq. in.	12.19	12.26	12.06	12.30	12.09
Fat thickness, in.[3]	0.85	0.78	0.78	0.76	0.82
Marbling[4]	14.8	14.3	14.0	13.7	15.4
Cutability, %	47.9	48.3	48.3	48.53	47.74

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low-prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8, low good-7.
[3] Average of three measurements determined on tracing at the 12th rib.
[4] Marbling scores: 1 to 30, 11 — slight, 14 = small, 17 = modest.

Influence Of Reconstitution On The Feeding Value Of Wheat For Finishing Cattle

Ryan Christiansen and Donald G. Wagner

Story in Brief

Wheat reconstituted by two different methods was compared to dry rolled wheat and dry rolled milo in high concentrate rations fed to finishing heifers in a 136 day feeding period. The treatments investigated in 90 percent concentrate rations were: 1) dry rolled milo, 2) dry rolled wheat, 3) whole-reconstituted wheat and 4) rolled-reconstituted wheat. In the reconstituted treatments the wheat was reconstituted to 30 percent moisture and stored for 21 days prior to feeding. The whole-reconstituted wheat was stored in the whole form and rolled just prior to feeding, while the rolled reconstituted wheat was rolled prior to reconstitution and storage. The wheat made up 70 percent of the total ration on a 90 percent D.M. basis.

Average daily feed intakes (90 percent D.M. basis) for the heifers on the dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat treatments were 17.6, 14.6, 14.7 and 15.8 lb., respectively, with the animals on the dry rolled milo treatment consuming significantly ($P<.05$) more feed than those on the three wheat treatments. Average daily gains were 2.78, 2.65, 2.49, and 2.70 lb. on the same treatments, respectively. None of the values for average daily gains were significantly different ($P>.05$) between treatments.

The average feed required per pound of gain was 6.34, 5.51, 5.90 and 5.86 lb. for the dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat treatments, respectively. All these values were significantly different among each treatment at the .05 level except for no significant difference ($P>.05$) between the whole-reconstituted wheat and rolled-reconstituted wheat treatments.

Introduction

In Oklahoma, wheat represents a major economic crop for farmers and is currently competitively priced with other grains used in feedlot rations, particularly during certain seasons of the year. Much of the previous work done with high concentrate beef cattle rations has involved either corn or milo. Research evaluating the use of reconstituted wheat for finishing beef cattle is very limited. A previous study investigating reconstitution of wheat for feedlot cattle suggested less response from reconstituting wheat than is normally obtained from reconstituting milo.

The objective of this experiment, therefore, was to further evaluate and compare the use of two different methods of reconstituting wheat with dry rolled wheat and dry rolled milo.

Materials and Methods

Forty-eight Angus feeder heifers averaging 408 pounds were selected for this experiment. During the three week preliminary period the animals were gradually adapted to a 90 percent concentrate ration.

After the preliminary period, the heifers were blocked into three groups on the basis of weight and then randomly allotted within blocks to four treatments with four heifers per pen (12 animals per treatment). The four treatments compared were as follows:

1) Dry rolled milo
2) Dry rolled wheat
3) Whole-reconstituted wheat
4) Rolled-reconstituted wheat

The dry rolled milo and dry rolled wheat were processed by rolling the grain through a 12 x 18" roller mill with a roller spacing of .003 inch. The reconstituted wheat treatments were obtained by reconstituting the wheat, whole or rolled, to 30 percent moisture by mixing the wheat with water in a cement mixer. The grain was then stored in airtight, plastic bags for 21 days before feeding. Temperature during storage was maintained at a minimum of 70° F. The rolled-reconstituted treatment was rolled before reconstituting; whereas, the whole-reconstituted wheat treatment was stored whole and rolled prior to feeding.

Compositions of the experimental rations are given in Table 1. All rations were formulated to contain the composition indicated on a 90 percent D.M. basis. The rations were formulated to contain 90 percent concentrate, with five percent cotton seed hulls and five percent pelleted alfalfa meal. For the three wheat treatments, wheat constituted 70 percent of the total ration on a 90 percent dry matter basis; dry rolled milo was included at a level of 14 percent in the wheat rations. The rations were formulated to be isonitrogenous. Diethylstilbestrol was fed at the level of 10 mg per head per day. Feed was prepared and fed daily in quantities adequate to permit availability of feed until the next feeding. Any feed which was refused during each feeding period was weighed back to assure a supply of fresh feed at all times.

Rumen fluid samples were collected on all the heifers twice during the feeding period for rumen pH and VFA determinations. pH values were determined on the rumen fluid samples immediately upon sampling. The rumen samples were then processed and stored for later VFA analyses.

Initial and final weights were taken full with a 4 percent pencil shrink. The feeding period for this experiment lasted 136 days. At the termination of the feeding trial, specific gravities were determined on each carcass to determine the net energy values of the feed using the comparative slaughter technique.

Table 1. Ration Composition[1]

Ingredient	Dry Rolled Milo Treatment	Wheat Treatments
Wheat	--	70.0
Milo	84.0	14.0
Premix[2]	16.0	16.0

[1] Formulated on a 90% D.M. basis.
[2] Contained cottonseed hulls, ground alfalfa hay, ground milo, soybean meal, urea, minerals, antibiotics, Vitamin A and diethylstilbestrol.

Results and Discussion

The proximate analysis data for the milo and wheat treatments are presented in Table 2. As can be noted for the table, the average moisture contents for the dry rolled milo, dry rolled wheat, whole reconstituted wheat and rolled reconstituted wheat were 87.24, 88.43, 68.64 and 67.71 percent, respectively. Particle size and weights per bushel are given in Table 3.

The feedlot performance data for the 136 day feeding period are shown in Table 4. The average daily feed intakes on the dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat treatments were 17.6, 14.6, 15.8 and 14.7 lb., respectively. The heifers on the dry rolled milo consumed significantly ($P<0.5$) more feed per day than those on the three wheat treatments. The average daily gains on the dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat treatments were 2.78, 2.65, 2.70 and 2.49 lb., respectively. These differences for rate of gain were not significant ($P>.05$). The significantly lower feed intakes on the three wheat treatments with nearly the same rates of gain were reflected in the pounds of

Table 2. Proximate Analysis of Milo and Wheat

Feed	Dry Matter	Crude Protein[1]	Ash[1]	Ether Extract[1]	Total CHO[1,2]
		percent			
Dry Rolled Milo	87.2	10.55[3]	1.26	1.56	86.63
Wheat		12.67[4]	2.44	1.20	83.89
Dry Rolled	88.4				
Whole-Reconstituted	68.6				
Rolled-Reconstituted	67.7				

[1] Values expressed on 100% D.M. basis.
[2] 100 — (Sum of figures for crude protein, ash and ether extract).
[3] 6.25 x percent Nitrogen = percent crude protein.
[4] 5.71 x percent Nitrogen = percent crude protein.

Table 3. Particle Size and Density of Processed Wheat

	Screen Size							
	4mm	2mm	1mm	500 micron	250 micron	125 micron	Through 125 micron	Wt. per Bu.
	% Retained						Through	lb.
DRM	0.1	7.5	73.8	9.2	3.0	2.1	4.6	37.8
DRW	0.1	45.7	33.5	9.5	4.4	2.8	3.9	34.6
RRW	8.4	77.6	12.4	0.9	0.4	0.2	0.1	30.0
WRW	28.5	65.8	4.7	0.7	0.2	0.1	0.0	28.7

Table 4. Feedlot Performance[1]

	Dry Rolled Milo	Dry Rolled Wheat	Whole Reconstituted Wheat	Rolled Reconstituted Wheat
No. of heifers	12	12	12	12
Initial Weight, lb.	409	408	406	410
Daily Feed, lb.[2]	17.55[a]	14.56[b]	15.76[b]	14.71[b]
Daily Gain, lb.	2.78	2.65	2.70	2.49
Final Weight, lb.	788	767	773	749
Feed/lb. Gain, lb.	6.34[a]	5.51[b]	5.86[c]	5.90[c]

[1] 136 days.
[2] Values without a common letter differ significantly (P<.05).

feed required per pound of gain, being 6.34, 5.51, 5.86 and 5.90 lb. for the same treatments, respectively. The feed efficiency values for dry rolled milo and dry rolled wheat differed significantly (P<.05) from each other and from the reconstituted wheat treatments. The two reconstituted wheat treatments, however, were not significantly different (P>.05).

As noted by the figures reported, the average daily gains for the animals on the three wheat treatments (70 percent wheat in the total ration) were .16 lb. per day less than on the milo treatment. Although the differences in rate of gain were not significant (P>.05) among the milo and wheat treatments in this experiment, (due likely to inadequate numbers), the slightly lower gain on the three wheat treatments is a trend which is consistent with observations in a number of other experiments conducted at Oklahoma State University in which 70 percent wheat was included in a finishing ration. In general, rations containing this level of wheat usually appear to lower gains approximately .10-.25 lb. per day as compared to all milo rations. Lower levels of wheat would, undoubtedly, produce less effect.

Net energy values for the different treatments are presented in Table 5. The values reported for the NE_{m+g} of the total ration and NE_{m+g} of the grain for the milo treatment were significantly lower (P<.05) than for the three wheat treatments. The NE_g values for dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat were 104.3, 122.5, 130.6 and 136.9 Megcal./100kg., respectively. The NE_g for dry rolled milo was significantly lower (P<.05) than for either of the reconstituted wheat treatments. No difference (P<.05) existed in the NE_g among any of the wheat treatments.

Rumen fluid pH values on the dry rolled milo, dry rolled wheat, whole-reconstituted wheat and rolled-reconstituted wheat treatments were 6.5, 5.7, 6.2 and 5.7 for the first sampling and 6.3, 6.8, 7.3 and 7.1 for the second sampling, respectively. These values did not differ sig-

Table 5. Net Energy Values

	Dry Rolled Milo	Dry Rolled Wheat	Whole Reconstituted Wheat	Rolled Reconstituted Wheat
NE_{m+g} Total Ration[1]	132.9[a]	151.2[b]	154.5[b]	159.3[b]
NE_{m+g} Grain[1]	139.3[a]	165.7[b]	170.3[b]	177.5[b]
NE_m Grain[1]	156.4	183.8	195.9	205.4
NE_g Grain[1]	104.3	122.5[a,b]	130.6[b]	136.9[b]

[1] Values without a common letter differ significantly (P< .05).

Table 6. Slaughter and Carcass Information

	Dry Rolled Milo	Dry Rolled Wheat	Whole Reconstituted Wheat	Rolled Reconstituted Wheat
Dressing, %[1]	62.04	59.24	61.67	61.35
Carcass grade[2]	9.25	9.08	9.58	10.50
Ribeye area, sq. in.	10.60	9.89	10.37	10.12
Fat thickness, in.[3]	0.81	0.65	0.69	0.71
Marbling[4]	14.66	14.25	15.41	18.41
Cutability, %	48.55	49.52	49.02	49.06

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8, low good-7.
[3] Average of three measurements determined on tracing at the 12th rib.
[4] Marbling scores: 1 to 30, 11 — slight, 14 = small, 17 = modest.

nificantly (P>.05) between treatments.

As noted in Table 5, no significant differences (P>.05) existed between carcass traits.

Briefly, this experiment would support the previously reported study suggesting little if any improvement in the nutritive value of wheat when wheat is reconstituted for feedlot cattle by the methods employed in this experiment. This is in contrast to observations with reconstituted milo.

Dry Processing Of Wheat For Finishing Beef Cattle

Donald G. Wagner, Ryan Christiansen and D. F. Stephens

Story in Brief

Four methods of dry processing wheat were compared with dry rolled milo in 90 percent concentrate rations for finishing beef cattle. The treatments investigated were 1) dry rolled milo, 2) dry rolled wheat, 3) coarsely ground wheat, 4) finely ground wheat and 5) whole wheat. The wheat treatments contained 70 percent wheat in the total ration. The rations were self fed.

In a 122 day steer feeding experiment, average daily feed intakes on a 90 percent D.M. basis were 20.8, 18.6, 20.7, 17.5 and 23.5 lb. for the dry rolled milo, dry rolled wheat, coarsely ground wheat, finely ground wheat and whole wheat treatments, respectively. The treatment differences in feed intake were significant ($P<.05$). Average daily gains were 3.01, 2.70, 2.86, 2.54 and 2.87 on these same treatments, respectively. Although not significant, the differences in gain closely approached the .05 level of probability. The pounds of feed required per pound of gain were 6.90, 6.93, 7.28, 6.89 and 8.19 for the above treatments, respectively. The cattle on the whole wheat consumed significantly more feed ($P<.05$) than on the other treatments.

Introduction

Wheat represents a major economic crop in Oklahoma with production approaching 100 million bushels annually in normal crop years. This is nearly four times the quantity of milo produced in Oklahoma. Due to the low wheat prices during the past few years and the readily available supply of wheat, considerable quantities of wheat have been and are being fed to feedlot cattle, especially during certain months of the year. Furthermore, high yielding varieties of wheat have been developed. Some of these varieties have poor milling and baking properties, but they might possibly be used as livestock feed.

Numerous processing methods have proven useful for improving the nutritive value of milo and some other grains for feedlot cattle. Little research is available, however, concerning the best method of processing wheat when fed in high concentrate rations to finishing cattle. It

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In cooperation with Agricultural Research Service, Animal Science Division, USDA.

is true that some grains are now being processed in more sophisticated ways than ever. Nevertheless, considerable interest exists on the part of many cattle feeders in processing grain in a manner which eliminates the need for elaborate, expensive equipment and in which self-feeding programs can be successfully used.

The recent interest in and widespread use of whole corn feeding programs is a case in point. Furthermore, research indicates that not all grains respond the same to processing. The objective of this experiment, therefore, was to determine the effect of various methods of dry processing wheat, including the use of whole wheat, when wheat is fed at a high level in a high concentrate ration to finishing cattle.

Materials and Methods

Equal numbers of choice Angus and Hereford feeder steers weighing approximately 680 lb. were selected for use in this experiment. The animals were gradually adapted to a 90 percent concentrate ration during the preliminary period.

Following the preliminary period, the animals were blocked into four groups on the basis of breed and weight. The animals were randomly allotted within blocks to five treatments with three steers per pen (12 animals per treatment). The five treatments were as follows:

1) Dry rolled milo
2) Dry rolled wheat
3) Coarse ground wheat
4) Fine ground wheat
5) Whole wheat

Dry rolled milo was included as one of the treatments to serve as a bench mark or basis of comparison for the high wheat rations in that considerable research has been conducted with dry rolled milo rations.

The milo and wheat for the dry rolled treatments were prepared by rolling through a heavy duty 18 x 24″ roller mill with a roller spacing of .003 inch. The wheat for the coarsely ground wheat treatment was obtained by grinding the wheat through a ½″ hammermill screen. The wheat for the finely ground wheat treatment was produced by grinding the wheat through a ⅛″ hammermill screen. The wheat in the whole wheat treatment was fed in the whole form. The wheat was of the Triumph variety, a hard winter wheat commonly grown in Oklahoma.

The compositions of the experimental rations are given in Table 1. The rations were formulated to contain the compositions indicated on a 90 percent D.M. basis; wheat represented 70 percent of the total ration

Table 1. Ration Composition[1]

Ingredient	Dry Rolled Milo Treatment	Wheat Treatments
	%	%
Wheat	---	70.0
Milo	84.0	14.0
Premix[2]	16.0	16.0

[1] Formulated on a 80% D.M. basis.
[2] Contained cottonseed hulls, ground alfalfa hay, soybean meal, urea, ground milo, minerals, antibiotics, Vitamin A and stilbestrol.

for all wheat treatment. All rations contained five percent cottonseed hulls and five percent coarsely ground alfalfa hay to produce a 90 percent concentrate—10 percent roughage ration. Dry rolled milo was included in all wheat treatment rations at a level of 14 percent of the total ration. Diethylstilbestrol was fed at a level of 10 mg per head per day. The rations were self fed; feeders were filled at approximately weekly intervals.

At two different times during the feeding period, approximately midway and near the end, rumen samples were obtained from each animal; pH values were determined immediately, and a small amount of rumen fluid was saved for VFA analyses.

Initial and final weights were taken full with a 4 percent pencil shrink. Animals in the heavy weight block were fed 112 days; animals in the light weight block were on feed 132 days, for an overall average of 122 days. Carcass specific gravities were determined on each animal at the end of the experiment to permit net energy estimations for the feed using the comparative slaughter technique.

Results and Discussion

The proximate analyses data for the milo and wheat are presented in Table 2. Particle size and densities of the processed grains are given in Table 3. As noted, substantial differences existed in the particle size distribution among the differently processed wheats. The dry rolled wheat and coarsely ground wheat had a rather similar particle size distribution, but the dry rolled wheat had a much lighter density than the coarsely ground wheat, with mean values of 33.1 and 44.6 lb. per bushel, respectively. The finely ground wheat, on the other hand, had a much smaller particle size, as measured in this experiment, than either the dry rolled or coarsely ground wheat. While the dry rolled and coarsely ground wheat had a similar particle size distribution, as measured in this study, it should be pointed out that particle size, as measured here, may

Table 2. Proximate Analysis of Milo and Wheat

Feed	Dry Matter	Crude Protein[1]	Ash[1]	Ether Extract[1]	CHO[1,2]
		percent			
Dry Rolled Milo[3]	88.3	13.05	1.81	2.62	82.88
Wheat[4]	88.8	12.98	2.31	1.82	82.89

[1] Values expressed on 100% D.M. basis.
[2] 100 — (Sum of figures for crude protein, ash and ether extract).
[3] 6.25 x percent Nitrogen = percent crude protein.
[4] 5.71 x percent Nitrogen = percent crude protein.

Table 3. Particle Size and Density of Milo and Wheat Treatments

	Screen Size							
	4mm	2mm	1mm	500 micron	250 micron	125 micron	Through 125 micron	Wt. per Bu.
Dry Rolled Milo	0.0	1.9	60.5	22.7	5.9	3.6	5.4	39.9
Dry Rolled Wheat	0.0	31.3	42.8	10.9	4.1	2.8	8.1	33.1
Coarse Ground Wheat	0.0	30.1	43.6	14.7	5.6	2.2	4.0	44.6
Fine Ground Wheat	0.0	0.2	12.0	24.1	21.5	15.4	26.8	46.4

[1] Expressed on a 90% D.M. basis.

not necessarily be a direct indicator of total surface area in the grain if rolling, for example, causes multifracturing of a particle. It is a commonly held opinion in the field that the particle size of wheat is not influenced measurably by the grinding or hammermilling conditions (screen size, etc.) due to the hard, flinty nature of wheat which tends to cause considerable shattering of the wheat kernel when subjected to force. This would be at variance with the particle size distributions reported in this study.

The feedlot performance data are shown in Table 4. The levels of daily feed intake (90 percent D.M. basis) were 20.8, 18.6, 20.7, 17.5 and 23.5 lb. per head on the dry rolled milo, dry rolled wheat, coarsely ground wheat, finely ground wheat and whole wheat treatments, respectively. Significant treatment differences ($P<.05$) existed in feed intake.

The average daily gains tended to be the highest on the dry rolled milo and lowest on the finely ground wheat, being 3.01, 2.70, 2.86, 2.54 and 2.87 lb. on the dry rolled milo, dry rolled wheat, coarsely ground wheat, finely ground wheat and whole wheat treatments, respectively. Although not significant, these differences in gain approached the .05

Table 4. Feedlot Permormance[1]

	Dry Rolled Milo	Dry Rolled Wheat	Coarse Ground Wheat	Fine Ground Wheat	Whole Wheat
No. of steers	12	12	12	12	12
Initial weight, lb.	693	693	688	688	685
Final weight, lb.	1058	1024	1033	1003	1038
Daily feed, lb.[2]	20.8[b]	18.6[a,b]	20.8[b]	17.5[a]	23.[c]
Daily gain, lb.	3.01	2.70	2.86	2.54	2.87
Feed/lb. gain, lb.[2]	6.90[a]	6.93[a]	7.28[a]	6.89[a]	8.19[b]

[1] 122 days.
[2] Uncommon letters differ at .05 level.

level of probability. The lowered feed intakes, gains and feed conversions observed on the finely ground wheat treatment may have been related to the fine, powdery nature of the ration resulting in reduced animal acceptance and palatability. Perhaps the inclusion of fat or molasses in such a ration to reduce dustiness and separation may improve performance when wheat is finely ground. The average rate of gain for the animals on all four wheat treatments (70 percent wheat in the total ration) was .26 lb. less than on the milo treatment. This observation is consistent with similar trends noted in other wheat feeding experiments at Oklahoma State; namely, rations containing 70 percent hard red wheat in the total ration usually reduced daily gains approximately .10-.25 lb. per head compared with milo rations.

Although not significantly different, the pounds of feed required per pound of gain appeared to be slightly in favor of dry rolling or fine grinding of wheat as compared with coarse grinding. This would agree with previous experimental observations on rolling and grinding of milo. Since the animals on whole wheat consumed significantly more feed ($P<.05$) and gained at approximately the same rate, the animals on whole wheat displayed a significantly poorer ($P<.05$) feed conversion than those on the remaining wheat and milo treatments. Approximately 1.2 lb. more feed were required per pound of gain on the whole wheat treatment. These data would suggest that wheat cannot be satisfactorily and economically fed in the whole form as can corn.

Mean pH values for the dry rolled milo, dry rolled wheat, coarsely ground wheat, finely ground wheat and whole wheat were 5.96, 5.79, 6.88, 5.66 and 6.75, respectively, for the first rumen sample collection period and 5.79, 6.11, 5.82, 5.80 and 6.69, respectively, for the second collection period.

Carcass characteristics are shown in Table 5. No significant differences ($P<.05$) existed among treatments.

Table 5. Slaughter and Carcass Information

	Dry Rolled Milo	Dry Rolled Wheat	Coarse Ground Wheat	Fine Ground Wheat	Whole Wheat
Dressing, %[1]	62.2	60.8	61.2	60.7	61.6
Carcass grade[2]	9.9	9.8	10.0	9.3	10.2
Ribeye area, sq. in.	12.2	11.4	11.8	12.2	12.1
Fat thickness, in.[3]	0.89	0.89	0.90	0.80	0.93
Marbling[4]	16.6	16.1	16.8	14.9	17.6
Cutability, %	47.65	47.70	47.62	49.18	47.55

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, average choice-11, low choice-10, good-9, average good-8 low good-7.
[3] Average of three measurements determined on tracing at the 12th rib.
[4] Marbling scores: 1 to 30, 11 — slight, 14 = small, 17 = modest.

Influence of Dietary Potassium Levels on Net K^{40} Count in Beef Steers

R. K. Johnson, L. E. Walters and J. V. Whiteman

Story in Brief

Thirty-six Angus-Hereford crossbred steers were used to study the influence of three levels of dietary potassium on net K^{40} count and blood serum and muscle tissue potassium concentrations. The experiment was balanced so that the carryover effect of each diet (the influence of a ration fed in one period on the measurements taken in the following period while steers were on another ration) as well as the direct effect of a diet could be evaluated.

Essentially no carry-over effect of diets was observed. Dietary potassium levels significantly affected K^{40} count of the steers, although they did not have a significant effect on blood serum or muscle tissue potassium levels. These data also indicated animal to animal variation in

potassium concentration may be an important source of variation in K^{40} estimates of fat-free lean in live animals. Thus, the experiment indicated that the primary influence of dietary potassium on K^{40} counting is the effect on the potassium content of the gastrointestinal tract and not on the potassium concentration of intracellular fluids.

Introduction

Recent research has indicated that the net K^{40} count measured by the OSU counter of a group of steers is reasonably accurate as a predictor of the average pounds of fat-free lean of steers in the group if all animals are managed alike prior to K^{40} counting. If the whole-body K^{40} counter is to become a usable tool to the cattle industry, it is necessary to determine whether or not the potassium level animals have received immediately prior to counting will influence the K^{40} count of those animals. If diet does influence count, then estimates of fat-free lean would depend to some extent on the amount of potassium in the diet. This would also mean that the accuracy of K^{40} comparisons of animals within a group would depend on whether or not all the animals were treated alike prior to counting.

This paper reports the results of an experiment conducted to evaluate the influence of dietary potassium on live animal net K^{40} count and blood serum and muscle tissue potassium concentrations of steers.

Materials and Methods

Three levels of dietary potassium were evaluated with 36 800 to 1000 pound Angus-Hereford crossbred steers. The diets, consisting of approximately 50 percent roughage-50 percent concentrate mixtures, were diet A, alfalfa-corn, diet B, wheat straw-corn, and diet C consisting of 1.7 pounds of KCl salt added to each 100 pounds of diet B. Potassium concentrations of diets A, B and C were 1.31, 0.29 and 1.03 percent, respectively. The experiment was conducted over eight weeks which were separated into four two-week periods. In the first two week period, all 36 steers received the same diet (a mixture of one-half diet A and one-half diet B). In each successive two-week period 12 steers were placed on each of the three diets. The steers were rotated to a different diet in each period so that at the completion of the study each steer had received each of the three diets.

At the end of each two-week period the steers were weighed and K^{40} counted while still on feed and water. They were then held off feed and water for 24 hours and again weighed and K^{40} counted. At this time blood samples were also collected to determine blood serum potassium concentrations. In addition to this, following the counting of each steer in the third period, a small sample of muscle tissue was surgically removed from the loin and analyzed for potassium content.

Results

Carry-over effect of a ration is defined as the increase or decrease caused by a ration fed in one period on a trait measured in the following period while the steer was on a different diet. These data were first analyzed to look at the size of the carry-over effect of each ration from one period to the next for each trait. If this value is small we can be reasonably assured that a measurement made in one period is the direct effect of the diet fed in that period and not a result of some carry-over from the diet fed in the previous period.

The carry-over effect means for each diet are presented in Table 1. In determining the relative importance of these means it should be noted that the overall averages for each trait are presented in the last column of the table. The importance of any one carryover mean can then be made by comparing its size relative to the size of the overall mean. If the carry-over effect mean is small in comparison to the overall mean, there is quite good evidence that little or no carry-over effect of the ration exists and that we can look at traits measured in any one period without being concerned about which diet was fed in the preceeding period. Also, if carry-over effects are unimportant, it means that animals that have been receiving different diets can be meaningfully compared based on K^{40} count if they are placed on a standard diet for a period of time prior to counting.

From comparison of these means it appears that the ration fed in any two-week period did not affect the measurements taken in the following period. This would indicate that feeding a standard diet for a two-week period prior to K^{40} counting would allow K^{40} comparisons to be made

Table 1. Carry-over Effect Means for Each Trait and Each Diet

	Diet			Overall Averages
	A	B	C	
Unshrunk Weight, lb.	3.03	—3.82	0.78	23.3[1]
Shrunk Weight, lb	0.51	—2.77	2.26	20.3[1]
Unshrunk Net K^{40} Count	—5.38	—98.96	104.33	13907.7
Shrunk Net K^{40} Count	0.85	—72.40	71.55	13137.8
Blood Serum Potassium, ppm	—1.48	2.33	—0.90	191.1

[1]The average increase in weight per diet for the entire experiment

among cattle within a group essentially free from the effects of previous diets these cattle may have received.

The diet averages for K^{40} count, blood serum potassium and muscle potassium are shown in Table 2.

It should be noted that regression analyses of these data indicated that as weight of the animals increased the K^{40} count also increased. Since there were differences in the weight gained by animals on each diet, this information was utilized to adjust the net K^{40} count means for the animals on each treatment to a constant weight so that more accurate treatment comparisons could be made.

Significant diet differences were found for both unshrunk and shrunk net K^{40} count means. The mean unshrunk net K^{40} count for diet A exceeded diet B by 447.5 counts per minute and diet B by 146.6 counts per minute. The diet C mean was also 301 counts per minute greater than the diet B mean. Differences between deit means were not as large after shrink. However, the differences of 133.5 and 218.0 counts per minute between the means of diets A and C and A and B, respectively, were still significant. There was a non-significant difference of 85.5 counts per minute between diets B and C.

Since diet significantly affected net K^{40} count it is interesting to compare estimates of fat-free lean from the shrunk mean net K^{40} count of each diet. This was done using prediction equations previously developed at Oklahoma State University with yearling Angus bulls. This resulted in fat-free lean estimates of 267.7, 264.5 and 265.8 pounds for the steers on diets A, B and C, respectively. Even though the differences in estimates are not large, this would indicate that the most accurate K^{40} comparisons among a group of cattle will be made when all animals of the group have been receiving the same diet for approximately two weeks prior to K^{40} counting. It would also indicate that the most precise estimates of fat-free lean in an animal will be made when that animal has received a diet similar in potassium content to the one on which fat-free lean prediction equations were developed.

Table 2. Average Net K^{40} Count[1], Blood Serum Potassium and Muscle Potassium Values for each Diet.

	A	B	C
Unshrunk K^{40} Count	14105.4	13657.9	13958.9
Shrunk K^{40} Count	13254.7	13036.7	13121.2
Blood Serum K, ppm	196.1	188.0	189.3
Muscle Tissue[2]	2.93	2.90	2.64

[1]) Adjusted for weight differences
[2]) Gms. potassium per kg. wet tissue

Potassium in the diet did not have a significant affect on either the blood serum or muscle tissue potassium concentrations This would suggest that the primary influence of dietary potassium to K^{40} counting is the effect on potassium in the gastrointestinal tract and not on the potassium concentration of fluids within the animals cells.

Analyses of these data also suggests that there are important animal to animal differences in potassium concentrations of the muscle and blood. It would appear that this is a major source of variation that affects the precision of K^{40} estimates of fat-free lean. Since K^{40} counting is done under the assumption that intracellular potassium concentrations are relatively constant, any variation that does exist between animals would cause K^{40} estimates of fat-free lean to differ to some extent from the exact value for that animal and may be a limiting factor to the precision of K^{40} estimates of fat-free lean in live animals.

The Ribonucleic And Deoxyribonucleic Acid Content Of Three Bovine Muscles At Various Post-Mortem Periods

J. J. Guenther

Story in Brief

The RNA and DNA concentration of mature bovine psoas major longissimus dorsi and biceps femoris muscles was determined at 0 hours (immediately post-mortem), 23 hours and 93 hours post-mortem. Results showed a significant ($P < .01$) difference in RNA concentration between test muscles which ranked biceps > longissimusi > psoas in the order of RNA content. RNA appeared to be directly related to in vivo activity and tenderness of the muscles. Also significant ($P < .01$) was the difference in RNA concentration at various times post-mortem. In general, the highest RNA concentration was observed at 23 hours and the lowest at 93 hours post-mortem.

No significant difference was noted between test muscles in DNA concentration; however, post-mortem aging caused a significant ($P < .01$) decrease in muscle DNA. RNA content was greater than DNA and the RNA-DNA ratio increased with post-mortem aging, suggesting greater DNase activity. The magnitude of the RNA-DNA ratio appeared to be directly related to in vivo muscle function.

Introduction

The role of nucleic acids in protein synthesis has been fairly well established. Deoxyribonucleic acid (DNA) is found in the nucleus of the cell and since skeletal muscles are multinucleated, DNA concentration should be greater in skeletal muscle than in mononucleated tissue. As the genetic information of a gene resides in the base sequence of the DNA molecule, DNA determines the specific structure of the Ribonucleic acid (RNA) produced by the cell, acting as a template.

RNA is contained mainly in the cell cytoplasm or muscle sarcoplasm and is associated with protein synthesis. Actual protein synthesis is believed to occur in the microsomes which are dispersed in the sarcoplasm and RNA directs the synthesis of the specific protein. It might be surmised that the very active muscles would contain more RNA than less active muscles.

Most studies in this area have been conducted on the tissue of various organs of laboratory animals such as mice, guinea pigs, etc. Thus, little is known regarding the quantitative amounts of nucleic acids in the skeletal muscle of the bovine. The purpose of this study was to determine the amount of DNA and RNA in certain bvoine skeletal muscles which were selected on the basis of their in vivo activity. Also, it was desired to assess the efficiency of the Schneider Hot Acid Extraction Method in quantitating nucleic acids from bovine muscle. Finally, various post-mortem "aging" periods were imposed to determine if nucleic acid quantity were affected by RNase and DNase activity.

Materials and Methods

Duplicate 40 gram samples were obtained from the longissimus dorsi, psoas major and biceps femoris muscles of a freshly killed, 900 lb. Hereford steer. The steer had been fed exclusively for show purposes. The samples were packaged and frozen at -20°F. Additional samples were taken from the above muscles at 23 hours and 93 hours post-mortem. During this time the carcass was held in a cooler at 34°F.

At the appropriate time, the samples were removed from the freezer, allowed to temper at 32° F. for one hour, then diced and blended into a homogenous paste via a Sorvall omni-mixer. This operation was done a 34°F. The method of Schneider (1964) was used to extract the nuclei acids from duplicate 1 gram aliquots of the muscle homogenate.

The orcinol colorimetric test of Ceriotti (1955) was used in th quantitation of RNA. It is pointed out, however, that increased repeat ibility was obtained if the samples were heated for 20 minutes at 212°F in an autoclave, rather than in the water bath as used in the abov method. The concentration of RNA was calculated from the formula RNA (mg/g sample) = O. D. x K. x D. F.; where O. D. = optica density (B & L Spectronic 20, 660mμ); K=O.D./1 mg RNA as calculate from the RNA standard; and D. F. = dilution factor required to put th 0.3 ml. aliquot on a 10 ml. basis.

The diphenylamine reaction of Siebert (1940) as modified by Burto (1956) was used to determine DNA. Again, the samples were heated fo 10 minutes at 212°F. in an autoclave rather than in the water bath. Th concentration of DNA, in mg/g sample, was calculated in the sam manner as that of RNA except that a 3 ml. aliquot was used for DNA an the dilution factor was thus altered.

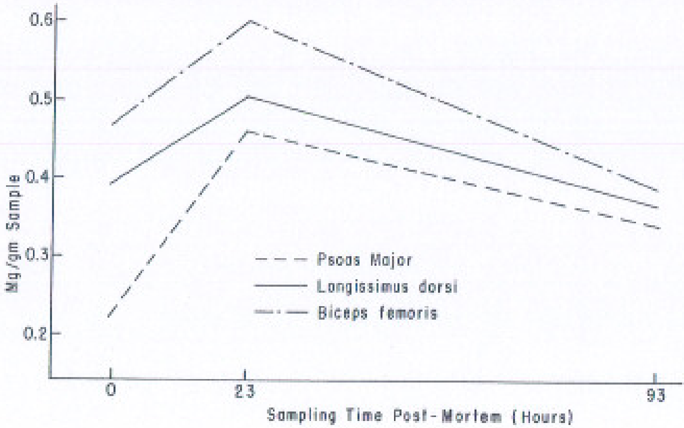
Results and Discussion

The analysis of variance for RNA concentration of the muscle sampled at 0, 23 and 93 hours post-mortem is given in Table 1. Thes results show a highly significant difference ($P < .01$) in RNA conten due to muscle and aging period. The mean values for RNA concentratio are presented graphically in Figure 1. Over all sampling periods, th Biceps, Longissimus and Psoas muscles averaged 0.486, 0.421 and 0.34 mg RNA per gm sample, respectively. These data suggest that the RN concentration of a particular muscle is related to the in vivo activity an function of the muscle. In this regard, the Biceps femoris, which had th highest concentration of RNA, is a very active muscle, used primarily t transport the animal. On the other hand, the Psoas, which had the lowes RNA concentration, is a relatively inactive muscle. While the Longiss mus dorsi, which was intermediate in RNA concentration, is considere

Table 1. Analysis of Variance For Ribonucleic Acid Content

Source	d.f.	Mean Square
TOTAL	17	------
Muscle	2	.03170**
Aging Period	2	.04985**
Muscle x Aging period	4	.00555
Duplicates (Error)	9	.00176

**$P < .01$.



igure 1. The influence of muscle and aging period on RNA concentration

› be more active than the Psoas but less active than the Biceps femoris. : is also interesting to note that in tenderness these three muscles would ınk as they did in RNA content.

It can be observed in Figure 1 that the RNA content of all muscles as greatest at the 23 hour sampling period and lowest, except for the soas, at the 93 hour period. The increase in RNA concentration observ-l at 23 hours post-mortem was attributed to a general increase in ex-actibility of nucleic acids at this time. While the decrease in RNA ›ntent between the 23 and 93 hour periods was believed to be a result of NA hydrolysis by inherent ribonucleases.

The analysis of variance of the DNA data is shown in Table 2 and ıe mean values are plotted in Figure 2. No significant differences were ›tained between the three muscles in DNA concentration. However, a ighly significant ($P < .01$) change in DNA could be attributed to the fect of aging period. Overall, the Longissimus, Psoas and Biceps muscles reraged 0.232, 0.226 and 0.219 mg DNA per gm sample, respectively. 'ith respect to the 0, 23 and 93 hour sampling periods the muscles aver-ged 0.257, 0.261 and 0.160 mg. DNA per gm sample, respectively.

As with the RNA results, DNA concentration, except for the Psoas uscle, increased between the 0 and 23 hour periods. However, all uscles sampled at 93 hours showed a decrease in DNA when compared › that obtained immediately post-mortem. Reasons for these changes ould be as stated for the RNA data, except that deoxyribonuclease :tivity would be responsible for the lowered DNA levels at the 93 hour st period.

Table 2. Analysis of Variance For Deoxyribonucelic Acid Content

Source	d.f.	Mean Square
TOTAL	17	------
Muscle	2	.00030
Aging Period	2	.01954**
Muscle x Aging Period	4	.00074
Duplicates (Error)	9	.00154

**P< .01.

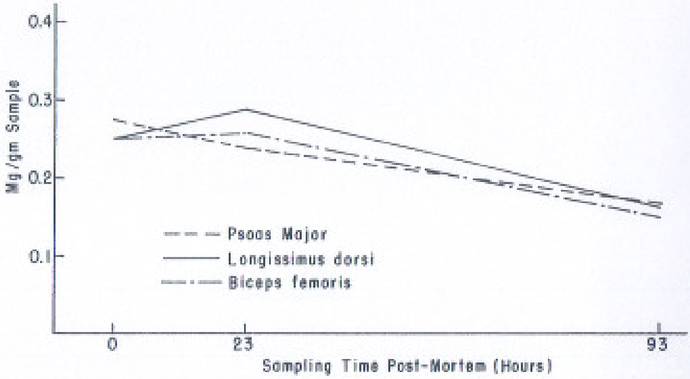


Figure 2. The influence of muscle and aging period on DNA concentration

In comparing the RNA and DNA results, it was noted that RNA concentration, except for the Psoas muscle at 0 hours, was greater than DNA concentration (Table 3). Also, the RNA to DNA ratio increased as aging time post-mortem was extended, suggesting that DNase activity was greater, relatively, than RNase activity. Finally, the magnitude of this ratio appeared to be directly related to in vivo muscle function.

Table 3. RNA - DNA Ratio

Muscle	Sampling Period		
	0 Hour	23 Hour	93 Hour
Psoas Major	0.82[1]	1.92	2.04
Longissimus Dorsi	1.57	1.75	2.26
Biceps Femoris	1.87	2.32	2.55

[1] Mg RNA/Mg DNA.

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Variation In Shear Tenderness Data

J. J. Guenther, J. D. Gresham and R. D. Morrison

Story in Brief

The inherent variation in shear tenderness data of longissimus dorsi muscle from the right and left sides of the bovine was assessed. Four right and three left L. dorsi muscles from seven, 1100 lb., choice grade steers comprised the experimental material for the study.

Results indicated considerable random variation in steak shear valves both along and across L. dorsi muscles and that shear value varied differently within each side, especially in the lumbar portion of the muscle. Overall, the right L. dorsi muscles averaged 1.6 lbs. greater shear force than did the left muscles. All muscles were more tender nearer the medial side.

Data suggest that the most efficient experimental design, to test the influence of various treatments on beef tenderness, would be the Latin square in which the treatment and control are alternated between muscles from the right and left sides. Results also indicate that to make valid inferences as to treatment influence on beef tenderness, it is neces-

sary to test an entire muscle such as the L. dorsi rather than a small portion of the muscle, such as the 9-10-11th rib, which has been customary procedure in the past.

Introduction

During recent years the beef industry has faced progressively stiffer competition from synthetic protein food products. To meet this competition, the beef industry must undertake measures to assure maximum quality in beef products at the retail level. As tenderness is the most important quality factor, it would be logical to devise chemical and/or physical treatments which would enhance this characteristic in all grades and cuts of retail beef. However, to properly evaluate the efficiency and effectiveness of any imposed tenderizing treatment, it is essential to appraise, first, the extent of variation in tenderness of untreated beef cuts and to identify the factors responsible for such variation.

The objective of this study was to assess the variation in tenderness of a suitable experimental unit, the bovine longissimus dorsi muscle.

Materials and Methods

Experimental material was obtained from four right and three left longissimus dorsi muscles from seven choice grade steers, weighing approximately 1100 lbs. alive. The muscles were removed as whole blocks immediately post-mortem, trimmed of subcutaneous fat, wrapped and stored at 37°F. for 96 hours. The seven muscle blocks (3 right and 4 left) from the contra-lateral sides were treated chemically for another phase of this study. At the appropriate time, each muscle was divided into 15 one-inch steaks (Figure 1). Each core was sheared once, at its center, via the Warner-Bratzler device. Results were expressed as units of resistance to shear. The data were analyzed according to Snedecor & Cochran (1967).

Results

The major objective of this phase of the experiment was to assess the inherent variation that occurred in shear value along and across the longissimus dorsi muscles from the right and left sides of the bovine. It was believed that this information would be pre-requisite to selecting an experimental design for the subsequent evaluation of treatment effects.

One method of appraising the above mentioned variation is by analyzing the shear values on a "by-side" basis and testing the homogeneity of variance in shear value within the right and left longissimus dorsi muscles. The results of these analyses are presented in Table 1. The

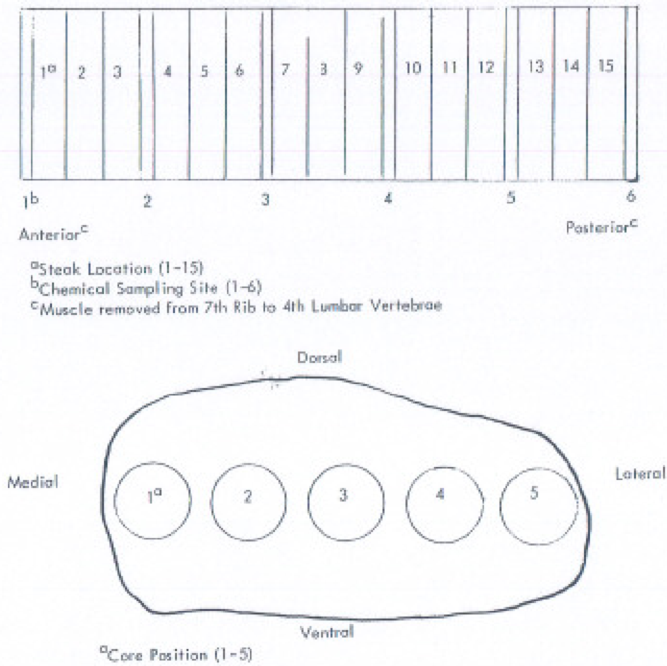

Figure 1. Schematic diagram showing the experimental model with respect to steak location within the L. D. muscle and core position within a particular steak.

only statistically significant source of variation noted in the analyses was that due to animal. As might be expected, this effect was quite large in both the right and left sides. These results also indicate a heterogeneity of variance between the right and left longissimus dorsi muscles for the animal x steak location, steak location x core position and animal x steak location x core position sources of variation.

In figure 2 the mean shear values for each of the fifteen steak locations along the right and left L dorsi muscles are presented. Though the analysis of variance (Table 1) showed no statistically significant difference in shear value due to steak location, these data suggest considerable random variation in steak shear value along the L. dorsi muscles from both sides. Also, the shear values appear to vary differently within each side, especially in the lumbar portion of the muscle. The maximum difference in shear force along the right and left muscle averaged 2.7 and 3.3 lbs., respectively. Overall the right L. dorsi averaged 1.6 lbs. more shear force than did the left. Perhaps if the number of animals were increased, a significant location effect would be obtained.

Table 1. Analysis of Variance For Shear Force By - Side

Source	d.f.	M.S.
Total	523	
Left Side	224	
Right Side	299	
Animal - in - left	2	944.8[1]
Animal - in - right	3	1817.8[1]
Steak location in left	14	14.6
Steak in right	14	17.9
Animal x steak location in left[2]	28	11.6[a]
Animal x steak location in right[3]	42	24.8[a]
Core position in left	4	12.8
Core position in right	4	36.0
Animal x position in left [4]	8	5.5
Animal x position in right[5]	12	13.2
Steak location x position in left	56	4.1[b]
Steak location x position in right	56	10.2[b]
Animal x steak location x position in left[6]	112	3.8[c]
Animal x steak location x position in right[7]	168	11.1[c]

[1] Significant ($P < 0.005$) difference in shear force among animals.

[2, 4, 6] Errcr term for left side.

[3, 5, 7] Error term for right side.

[a, b, c] Common superscript indicates unequality of variance.

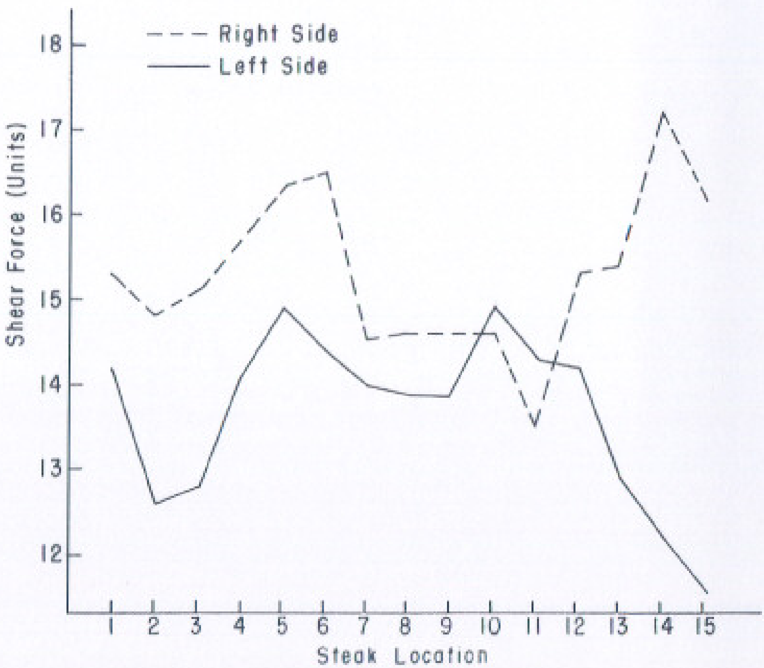

Figure 2. Mean shear values plotted by steak location along the right and left longissimus dorsi muscles.

Figure 3 portrays the average shear values plotted by core position within each steak from the right and left muscles. As indicated by these data, both right and left L. dorsi muscle seem to be more tender nearer the medial side, with the right side muscles having the higher shear values. The maximum difference in shear force between the two sides, 2.1 lbs., occurred at the lateral - most position. Again, the shear values tended to vary differently with side.

Discussion

As stated earlier, this study was conducted to determine the most efficient experimental design to test the influence of various chemical treatments on beef tenderness. The most frequently used experimental design in studies of this nature is a split - plot technique in which a portion of the longissimus dorsi muscle from one side of the animal is treated and the contra - lateral muscle portion is used as the "untreated control". The basic assumption in this technique is that there are no inherent differences between the right and left sides in the variable (such as tenderness) under investigation. This type of design, however, could lead to an unintentional confounding of the results with any side differences. For the results of the present study suggest that tenderness may vary not only between sides but also it may vary in different directions along and across the right and left longissimus dorsi muscles. Also, the

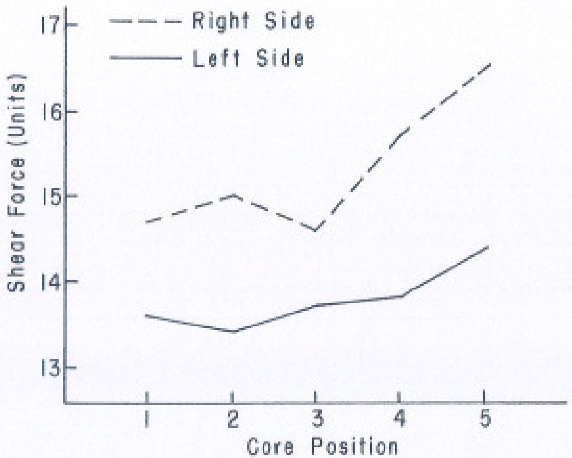

Figure 3. Mean shear values plotted by core position within steaks from the right and left longissimus dorsi muscles.

contra - lateral technique would require large numbers of animals to assess treatment effects.

The present results indicate that a more efficient design would be the Latin Square in which the treatment is assigned alternately to a particular side, and an even number of animals are added to the test. In this procedure the control side is also alternated between right and left. Moreover, the Latin Square design would require a minimum number of animals to assess animal, side and treatment effects.

The current data also suggest that if inferences are to be made to the effect of a particular treatment on beef tenderness in general, if would be wise to test an entire muscle such as the longissimus dorsi rather than a small portion of the muscle, such as the 9-10-11th rib, which has been the customary procedure in the past.

The Influence Of P-Chloromercuribenzoate On The Tenderness, pH, Adenosine Triphosphatase Activity And Protein Solubility Of Bovine Longissimus Muscle

J. D. Gresham, J. J. Guenther and R. D. Morrison

Story in Brief

This experiment was conducted to study the effect of a particular level of p-chloromercuribenzoate on the tenderness and certain biochemical attributes of beef muscle. Results showed that PCMB, as used in this test, had no statistically significant effect on the shear force, calcium or magnesium activated myofibrillar ATPase activity, pH or myofibrillar protein solubility of bovine longissimus dorsi muscle.

Introduction

Tenderness is the major quality attribute of beef and is supposedly influenced by the degree of post-mortem contracture of muscle and the subsequent formation of the actomyosin complex post-mortem. It follows, then, that inhibition of the above phenomena could lead to improved beef tenderness. Thus, the objective of this study was to determine the effect of a known sulfhydryl inhibitor, p-chloromercuribenzoate (PCMB), on the tenderness and on certain chemical attributes of bovine longissimus dorsi muscle.

Materials and Methods

Experimental material was obtained from the longissimus dorsi muscles of two, choice grade steers, weighing approximately 1100 lbs. alive. One side of each animal was designated for treatment, with the contra-lateral side serving as the untreated control. Treatment was alternated between right and left sides of experimental animals. The muscles were removed as whole blocks immediately post-mortem, trimmed of subcutaneous fat and weighed. The control muscles were wrapped and stored at 37° F. for 96 hours. The treatment muscles were injected with para-Chloromercuribenzoate (PCMB) to a final concentration of 5.0 x 10^{-4}m M in a volume of 15 percent of the original muscle weight. The solution was injected with a 50cc. hypodermic syringe fitted with a 6 inch needle. After injection the muscle was wrapped and stored identical to the control muscle.

At the appropriate time, each muscle was divided into 15 one inch steaks. Samples for chemical evaluation were also removed at this time, as shown in Figure 1. The steaks were fitted with individual thermometers and cooked to a center temperature of 160°F. in an oven which had been preheated to 300°F. Upon attaining the desired center temperature, the steaks were removed from the oven and five, ¾ inch diameter cores were removed, successively, along the dorsal-ventral midline of each steak, beginning at the medial side and terminating at the lateral side (Figure 1). Each core was sheared once, at its center, via the Warner-Bratzler device. Results were expressed as units of resistance to shear.

Samples for chemical evaluation were stored at 32°F. until required for analysis. At the appropriate time, the samples were removed from storage, thawed at 37°F. and analyzed for pH, myofibrillar adenosinetriphosphatase (ATPase) activity, and protein solubility. Samples were removed and analyzed at three time periods. Time "1" was immediately post-mortem before injection with PCMB, Time "2" was upon removal

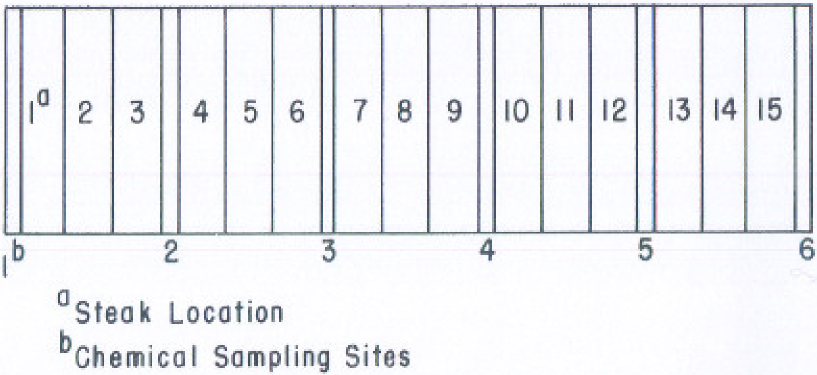

Figure 1. Schematic illustrating steak locations and sampling sites.

from storage, and Time "3" was after storage at 32°F. Samples analyzed for Time effect were from sites 1 & 6 only (Figure 1). Samples analyzed for location effect were from sites 1-6, and all were analyzed after freezer storage.

Results and Discussion

The objective of this study was to establish the influence of a particular level of PCMB on tenderness and certain chemical attributes of bovine longissimus dorsi muscle.

The results of this study indicated no statistically significant effect of PCMB on tenderness. There was a statistically significant ($P<0.005$) effect on core position within the muscles, with the medial side being more tender than the lateral side. No statistically significant difference in tenderness due to steak location along the length of the muscle was noted.

ATPase activity was determined using both a Ca^{++}-activated high ionic strength system, and a Mg^{++}-activated low ionic strength system. Theoretically, it was believed that the Ca^{++} system would stimulate free myosin ATPase activity, while the Mg^{++} system would activate myofibrillar (actinmyosin complex) ATPase activity. Thus, if PCMB inhibited formation of actomyosin, the phenomenon could be detected by a low Mg^{++} activation and no decreased Ca^{++} stimulation. Results of this study indicated no significant effect on any parameter studied on the Ca^{++} activated system. However, there was a significant time effect on the Mg^{++} activated system in both treated and control muscles (Figures 2 and 3). This indicates that PCMB did not inhibit the formation of the

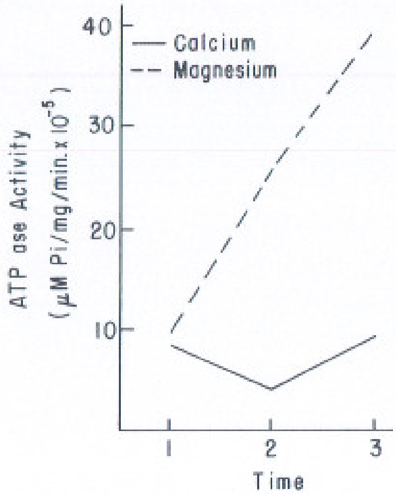

Figure 2. Influence of time on myofibrillar ATPase activity of PCMB treated muscles.

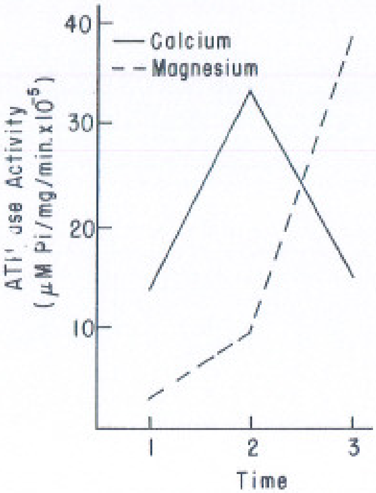

Figure 3. Influence of time on myofibrillar ATPase activity of control muscles.

actomyosin complex, as indicated by increased activity at time 2 and 3. Further study would be necessary to explain the large increase in activity between times 2 and 3, since the only difference between the two is freezing.

Results of analysis of the pH data indicated no significant variation in pH at the various sampling sites along the length of the muscle in either treated or control sides. However, there was a significant variation in pH with time with a drop in pH from approximately 6.4 at time "1" to a pH of 5.3 at times "2" and "3" (Figure 4). There was no significant treatment effect on muscle pH.

Analysis of the myofibrillar protein solubility data indicated no significant treatment effect on the solubility of the myofibrillar protein.

Summary

It is apparent from the results of this study that the level of PCMB used (5×10^{-4}mM) had no significant effect on tenderness or pH of bovine longissimus dorsi muscle or on myofibrillar protein ATPase activity or solubility. From a theoretical standpoint these results were somewhat unexpected, since PCMB is purportedly an efficient sulfhydryl group

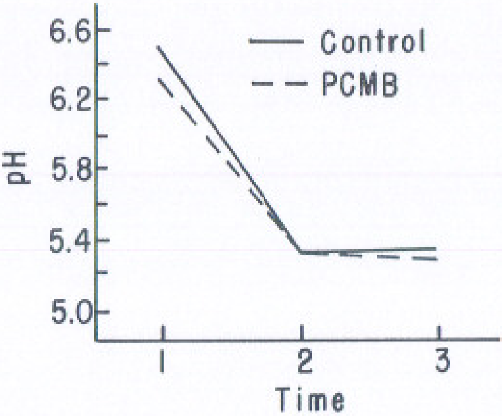

Figure 4. Influence of time on pH.

inhibitor. Perhaps the level of PCMB utilized was insufficient to effect significant mercaptide formation or the method of application of the test chemical or the handling of the treated samples did not allow sufficient reaction to occur.

Using Live K^{40} Count To Estimate Leanness In Pigs

C. E. Addison, I. T. Omtvedt, L. E. Walters, R. K. Johnson and R. F. Queener

Story In Brief

A total of 155 market pigs from the swine breeding herds were evaluated for live K^{40} count at the Live Animal Evaluation Center and then slaughtered at the University Meat Laboratory. All animals were evaluated for K^{40} content for a five minute period with background counts taken before and after each pig was counted. To determine the repeatability of the counts obtained, the pigs in 1970 were randomly allotted to the counter for a second 5-minute evaluation period. The correlation between first and second reading on the same pigs were 0.91, indicating a relatively high degree of repeatability.

The pigs were slaughtered the day after being evaluated by the K^{40} counter. After chilling, the carcasses were cut and the weights of closely trimmed hams, loins and shoulders were obtained. Determination of the fat-free lean content from ether extract analyses were made for the 59 pigs evaluated in 1970.

The pooled within breed correlation between live K^{40} count and fat-free lean for the pigs evaluated in 1970 was 0.89, thus accounting for 79 percent of the variation. The correlations between live K^{40} count and total separable lean and total lean cuts were 0.79 and 0.73, respectively. Net live K^{40} count was more closely correlated with lean yields than was either carcass backfat or loin eye area. Carcass backfat accounted for about 25 percent of the variation in lean yields compared to only 12 percent for loin eye area. The correlation between K^{40} net count and total lean cuts for the pigs evaluated in 1971 was 0.58. This correlation was lower than expected due to monitoring difficulty with the analyzer.

The prediction equation using only live K^{40} count to estimate fat-free lean content accounted for 80 percent of the variation with an average error of 2.8 lbs. Although the degree of accuracy was lower during the second period, these data do indicate that the whole body scintillation counter can be a valuable tool in estimating the amount of lean tissue on live animal.

In cooperation with Agriculture Research Service, Animal Science Research Division, USDA.

Introduction

Ultrasonic measurements of backfat thickness and loin eye area are useful aids in swine breeding but these traits are only estimates of the amount of lean in an animal. Previous work at this station has indicated that the K^{40} whole body scintillation counter may be a reliable instrument for estimating the amount of lean in a live animal.

This study was initiated to evaluate the relationship between K^{40} net counts of live pigs and their carcass data and to develop prediction equations for estimating the amount of lean in the live animal using live K^{40} net counts.

Materials and Methods

A total of 155 pigs were evaluated consisting of 47 barrows and 12 gilts in 1970 and 96 barrows in 1971. The distribution of the pigs by breed group and year is given in Table 1. All pigs were produced in the swine breeding project herds and were self-fed from weaning at six weeks until they weighed approximately 220 lbs. Pigs were removed from test on a weekly basis and held off feed for 24 hours prior to being evaluated for K^{40} count at the University Live Animal Evaluation Center.

Each animal was evaluated using five 1-minute counts with background counts taken before and after the pig was confined to the chamber. To determine the repeatability of the count obtained, the 59 pigs evaluated in 1970 were randomly allotted for counting for a second 5-minute evaluation period. The correlation between first reading and second reading on the same pig was 0.91, thus indicating a high degree of repeatability in obtaining live K^{40} counts. Only one 5-minute counting period was used in 1971.

All pigs were slaughtered at the University Meat Laboratory the

Table 1. Distribution of Pigs Evaluated by Year and Breed Group

Breed Group	Year 1970	Year 1971
Duroc	18	12
Hampshire	21	12
Yorkshire	20	12
Duroc-Hamp Cross	--	20
Duroc-York Cross	--	20
Hamp-York Cross	--	20
	59	96

day after being evaluated by the K^{40} counter. After a 24-hour chill, the carcasses were cut into wholesale cuts and weights of the closely trimmed hams, loins and shoulders were obtained. Carcass length, backfat and loin eye area measurements were made.

Fat-free lean estimates were obtained from the 59 pigs evaluated in 1970. The separable lean, fat and bone were obtained from the right side of each carcass and the separable lean was thoroughly ground and mixed for ether extract determinations. Fat-free lean was then determined by subtracting the estimate of the fat in the lean from the separable lean. The 1971 data were adjusted for sex and breed effects using least squares analyses. The means and standard deviations for the two groups are presented in Table 2. There was more variation in the net K^{40} counts obtained among the pigs evaluated in 1971 than among those evaluated in 1970, but there was less variation in total weights of lean cuts in 1971 than in 1970.

Results and Discussion

The pooled within breed correlations for each group are presented in Table 3. Of the measures of leanness, fat-free lean was more closely related to net K^{40} count than was lean or total lean cuts. This would be expected since it is the best measure of the total lean mass of the animal. Because of the time and expense involved, fat-free lean determinations were obtained only in 1970. Live net K^{40} count accounted for 79 percent of the variation in fat-free lean compared to 62 percent of the variation in total separable lean and only 53 percent of the variation in total lean cuts. In 1971 the correlation between net live K^{40} count and yield of total lean cuts was only 0.58, thus accounting for only 34 percent of the variation.

Table 2. Means and Standard Deviations for Traits Evaluated

Trait	1970* Mean	1970* Standard Deviation	1971 Mean	1971 Standard Deviation
Shrunk live wt., lb.	225.7	8.0	210.2	6.1
Carcass backfat, in.	1.05	0.20	1.24	0.14
Loin eye area, sq. in.	4.43	0.57	4.84	0.55
Ham, loin, shoulder wt., lb.	86.1	5.10	85.0	4.19
Total separable lean, lb.	97.2	6.42		
Total fat-free lean, lb.	82.5	6.83		
Net live ^{40}K count	6255	585	5747	630

* Gilt data adjusted to barrow equivalent on a within basis.

For the 1970 pigs live net K^{40} count was more closely correlated with measures of lean yields than was either carcass backfat or loin eye area. Carcass backfat thickness accounted for approximately 25 percent of the variation in lean yield while loin eye area accounted for only 12 percent of the variation. Among the pigs evaluated in 1971, both loin eye area and net K^{40} count accounted for 34 percent of the variation in total lean cuts, while carcass backfat accounted for only 16 percent of the variation.

Since fat-free lean determinations were not obtained in 1971, only the 1970 data were used in calculating prediction equations. Least squares analysis adjusting for breed and sex was used. When slaughter weight was combined with count, neither the amount of variation accounted for or the average miss were changed significantly, so the equations shown in Table 4 involve only live count. As would be expected, the amounts of variation accounted for were smaller and the average misses larger when predicting total lean cuts or total separable lean as compared to fat-free lean.

These results suggest that the K^{40} count on live pigs can be a valuable aid in selecting animals with more lean. Continued research is needed to identify factors that may influence counting efficiency.

Table 3. Pooled Within Breed Correlations Among Various Evaluation Measurements and Carcass Cut-Out Data

Measurements	1970 Data			1971 Data
	Fat-Free Lean	Total Separable Lean	Total Lean Cuts	Total Lean Cuts
Live ^{40}K count	.89**	.79**	.73**	.58*
Carcass backfat thickness	—.57**	—.51**	—.53**	—.40*
Loin eye area	.35**	.35**	.37**	.58*

* Significant at 5% level.
** Significant at 1% level.

Table 4. Prediction Equations for Measures of Leanness Using Net Live ^{40}K Count

Prediction Equations	% of Variation Accounted For	Average Miss
Pounds of Lean Cuts: 43.876 + 0.00676 (^{40}K Count)	55	3.1 lbs.
Pounds of Separable Lean: 39.885 + 0.00912 (^{40}K Count)	63	3.7 lbs.
Pounds of Fat-Free Lean: 14.102 + 0.01093 (^{40}K Count)	80	2.8 lbs.

Influence of Feeding Sequence During Pregnancy On Reproductive Performance of Sows

L. Keith Caldwell, I. T. Omtvedt and R. R. Wilson

Story in Brief

Two trials were conducted at the Fort Reno Experiment Station to determine the effects of feeding sequence during gestation on the reproductive performance of sows. In trial I, 60 sows were allotted at the time of breeding to one of three treatments: 1. Hand-fed everyday; 2. Hand-fed three times a week (Monday, Wednesday and Friday); and 3. Access to self-feeders for 3 hours three times a week (Monday, Wednesday and Friday). In trial II, 27 sows were assigned at the time of breeding to either the daily hand-feeding or three times a week hand-feeding regime. Sows in both trials were bred during February and March for summer litters. All sows were fed a 16 percent milo-wheat-soybean ration.

The self-fed sows gained significantly more weight during gestation (166.8 lb. compared to 80.7 lb. for the every-day feeding and 70.9 lbs. for those hand-fed three times a week). Sow condition score at farrowing was also significantly higher for the self-fed sows. Birth weights were heavier for pigs farrowed by self-fed sows but differences in litter size were not significant. However, there was a tendency for litter size to be larger for every-day feeding (11.6 pigs/litter) and smaller for self-feeding (10.5 pigs/litter). Differences between sows hand-fed daily and those hand-fed three times a week were not significant in either trial, but productivity tended to consistantly favor those that were daily-fed.

Introduction

Keeping labor requirements to a minimum and sow productivity at a maximum is of great economic importance. As a means of reducing labor input, many swine producers have gone to some type of interval feeding system for their sows during gestation. However, the influence of feeding

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sequence on reproductive performance is not fully understood. The advantages of interval feeding from a labor standpoint are readily apparent but more work is needed before it can be recommended from a reproductive efficiency standpoint. This study was initiated to determine the effects of interval feeding on sow condition, farrowing results and 21-day pig performance.

Materials and Methods

A total of 60 Duroc-Beltsville No. 1 crossbred sows were used in trial I. All sows had raised one litter before being allotted to this study. Two weeks prior to breeding, all sows were fed 6 lb. of a 16 percent protein ration daily until they were bred. At the time of breeding, sows were allotted to one of three treatments: 1. Hand-fed every day; 2. Hand-fed every Monday, Wednesday and Friday; or 3. Given access to a self-feeder for 3 hours every Monday, Wednesday and Friday. Two gestation lots were used for each treatment with 10 sows per lot. The sows consumed an average of 4.3 lb., 4.4 lb. and 8.4 lb. of feed per head per day during gestation on treatments 1, 2 and 3, respectively. The sows remained on their respective treatments until 109 days postbreeding. The breeding season started on February 15, and all sows were bred within a six-week period.

Information was obtained on gestation gain, sow scores, farrowing results and 21-day pig performance.

In trial II, 27 second-litter Hampshire sows were utilized. All sows were fed the same ration and were managed and allotted to treatment in the same manner as in trial I, but treatment 3 was eliminated. The breeding season for this trial also started on February 15, and continued for six weeks.

Sow gestation gain, sow condition score at farrowing and litter production were evaluated in both trials.

Results and Discussion

The results for trial I are summarized in Table I. The self-fed group consumed an average of 8.4 lbs. ration per day during gestation which was nearly twice as much as for the two limited-fed groups. The self-fed sows had significantly higher gestation gains, sow condition scores and pig birth weights. Even though there was not a significant difference in litter size at farrowing, there was a tendency for the fatter sows to farrow fewer pigs. This factor, plus the extra feed costs resulting from the additional feed consumed by the self-fed sows, makes this system economically unfeasible. It should also be pointed out that the self-fed sows were under

Table 1. Comparison of Every Day Feeding, Three Times A Week Feeding and Self-Feeding in Trial I

					Farrowing Data				21-Day Data			
Treatment	No. Sows	Feed Per Day lb.	Sow Gestation Gain lb.	Sow Farrowing Condition Score[5]	Live Pigs/ Litter	Pig Weight lb.	Litter Weight lb.	Survival first 24 hrs.	No. Pigs/ Litter	Pig Weight lb.	Litter Weight lb.	% Survival
Hand Fed Daily	20	4.3	80.7[1]	4.6[1]	11.6	2.90[1]	34.5	99.3	10.4	12.4	128	91.2
Hand Fed 3 times/week	19[3]	4.4	70.9[1]	4.8[1]	11.0	2.83[1]	32.3	97.9	9.6	11.3	114	83.4
Self Fed 3 times/week	18[4]	8.4	166.8[2]	6.7[2]	10.5	3.22[2]	35.0	99.5	8.8	13.0	111	85.8

[1,2] Values with different superscripts within a column significantly different (P< .05).
[3] One sow failed to breed.
[4] Two extremely fat sows died from heat exhaustion in farrowing house prior to farrowing.
[5] 9 denotes excessively fat and 1 denotes extremely thin with 5 being average.

Table 2. Comparison of Every Day Feeding and Three Times A Week Feeding in Trials I and II

					Farrowing Data			
Trial	Feeding Sequence	No. Sows	Average Sow Gestation Gain[1] lb.	Sow Condition Score Farrowing[2]	No. Live Pigs Litter	Pig Weight lb.	Litter Weight lb.	% Survival first 24 hrs.
I	Daily	20	80.7	4.6	11.6	2.9	34.5	99.3
	3 times/week	19	70.9	4.8	11.0	2.8	32.3	97.9
II	Daily	14	56.9	5.9	9.4	2.9	27.6	84.2
	3 times/week	13	45.9	6.0	8.0	3.0	25.7	88.8
Overall	Daily	34	70.9	5.2	10.7	2.9	31.6	93.0
	3 times/week	32	60.8	5.3	9.8	2.9	29.6	94.2

[1] 109 day weight minus breeding weight.
[2] 9 denotes excessively fat and 1 denotes extremely thin with 5 being average.
[3] Differences between trials significant for all variables measured except pig birth weight.

greater stress when confined to the farrowing crates prior to farrowing and two sows in treatment 3 died prior to farrowing.

The results of daily hand feeding compared to hand feeding 3-times weekly are given in Table 2. Although there were no significant differences between the treatments, there was a trend for the daily fed sows to farrow more live pigs (11.1 pigs/litter) than the three times a week fed sows (10.2 pigs/litter). The differences between trials were significant, but the relative differences between treatments within each trial were similar.

These results suggest that no drastic reduction in productivity occurs when sows were fed only three times a week instead of daily. However, it was economically unfeasible to self-feed sows a high energy ration even when access to feeders was limited to 3 hours three days a week.

Effects of Levels of Protein and Lysine Supplementation To Wheat Rations For Growing-Finishing Swine

W. G. Luce, I. T. Omtvedt and R. R. Wilson

Story in Brief

Two hundred eighty-eight pigs were fed during the winter of 1970-71 at the Fort Reno Livestock Research Station to evaluate different levels of protein and lysine supplementation to wheat rations as compared to a basal milo ration. The pigs were self-fed in confinement from an average weight of 56.0 pounds to 219.8 pounds.

The supplementation of L-lysine, or additional soybean meal, to increase the lysine level of wheat rations to 0.6 percent, or higher, improved average daily gains. A level of 0.6 percent lysine was as effective as 0.7 percent as measured by rate of gain for pigs fed wheat rations.

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Furthermore, this study demonstrated that a portion of the soybean meal in a 16 percent crude protein wheat ration could be effectively substituted with synthetic L-lysine. No significant differences were noted in feed efficiency, average daily feed intake, or probed backfat thickness among pigs fed any of the wheat rations or the milo ration.

Introduction

Wheat is often competitively priced with other cereal grains in Oklahoma to justify its use as a feedstuff in swine rations. Wheat, as other cereal grains, must be supplemented with additional protein to meet the essential amino acid requirements of swine if optimum performance is desired. The purpose of this study was to evaluate different levels of protein and lysine supplementation to wheat rations as compared to a basal-milo ration for growing-finishing swine. The study also explored the possibility of substituting synthetic lysine, one of the essential amino acids deficient in wheat, for a portion of the soybean meal normally included in a wheat ration for growing-finishing swine.

Experimental Procedure

Two hundred eighty-eight Hampshire x Duroc-Beltsville pigs were used in this study. The pigs averaging 56.0 pounds were randomly alloted within sex and litter to six experimental treatments. Each experimental treatment consisted of three replicates containing 16 pigs each (eight barrows and eight gilts). The pigs were housed and group-fed in indoor concrete pens equipped with self-feeders and automatic waterers. Pigs were individually removed from test and probed for backfat thickness on a weekly basis when they reached 220 pounds.

Composition of the experimental rations fed are shown in Table 1. The hard red winter wheat (Triumph variety) and milo analyzed 13.6 and 8.4 percent crude protein, respectively. Ration 1 was a 15.0 percent crude protein milo-soybean meal basal ration that calculated 0.79 percent lysine. Rations 2, 3, and 4 were 15.0 percent crude protein (0.50 percent lysine) wheat rations with 3 and 4 being supplemented with an additional 0.1 and 0.2 percent L-lysine, respectively. Rations 5 and 6 had additional soybean meal added at the expense of wheat to bring the crude protein levels to 16.0 and 17.0 percent, respectively. The additional soybean meal in Rations 5 and 6 made the total lysine level of these rations approximately equal to Rations 3 and 4. Thus, Rations 3 and 5 contained approximately 0.6 percent lysine and Rations 4 and 6 contained 0.7 percent lysine.

Table 1. Composition of Experimental Rations

Ingredients, percent	Ration number 1	2	3	4	5	6
Wheat, ground	----	88.10	87.80	87.50	85.00	81.70
Milo, ground	75.30	----	----	----	----	----
Soybean meal, 44%	19.70	6.90	6.20	5.50	10.10	13.40
Molasses	1.50	1.50	1.50	1.50	1.50	1.50
Dicalcium phosphate	1.50	1.40	1.40	1.40	1.30	1.30
Calcium carbonate	0.80	0.90	0.90	0.90	0.90	0.90
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin-TM premix[1]	0.50	0.50	0.50	0.50	0.50	0.50
Tylan 10	0.20	0.20	0.20	0.20	0.20	0.20
Lysine mix	----	----	1.00	2.00	----	----
Total	100.00	100.00	100.00	100.00	100.00	100.00
Composition						
protein, %	15.00	15.00	15.00	15.00	15.00	15.00
lysine, %	0.79	0.50	0.60	0.70	0.59	0.69
calcium, %	0.70	0.70	0.70	0.70	0.70	0.70
phosphorus, %	0.60	0.60	0.60	0.60	0.60	0.60

[1] Vitamin-trace mineral premix supplied 1,500 IU Vitamin A, 150 IU Vitamin D_2, 2 mg. riboflavin, 15 mg. niacin, 10 mg. pantothenic acid, 500 mg. choline, 7.5 mcg. Vitamin B_{12}, 0.22 ppm iodine, 99 ppm iron, 22 ppm manganese, 11 ppm copper, and 99 ppm zinc per pound of feed.

Results and Discussion

The results of this experiment are presented in Table 2. Pigs on Treatment 2 (wheat-15 percent crude protein) gained significantly less than the pigs on the other treatments. The calculated low level of lysine (0.5 percent) in this ration appears to be the plausible explanation for the reduced gain. The pigs on the basal grain sorghum ration (Treatment 1) had the highest average daily gains and was significantly greater than those on the 15, 16, and 17 percent wheat rations (Treatments 2, 5, and 6 respectively).

It appears that the addition of synthetic lysine to raise the lysine content of Rations 2 and 4 to 0.6 and 0.7 percent, respectively, was effective in increasing gains. A level of 0.6 percent appeared to be as effective as 0.7 percent. Although the additional increase of soybean meal in Rations 5 and 6 to raise the lysine level to 0.6 and 0.7 percent, respectively, did increase gain, it did not appear to be as effective as was the addition of L-lysine in Rations 3 and 4. This suggest that the lysine in soybean meal may not be as available to the pig as synthetic L-lysine.

No significant differences were noted among treatments for feed required per pound of gain, average daily feed intake, or probed backfat thickness. However, pigs on Treatment 2 (wheat-15 percent crude protein) tended to have poorer feed conversion and lowered feed intake.

Table 2. Effect of Lysine and/or Soybean Meal Supplementation to Wheat Rations on Pig Performance

Treatment	1 (15% milo)	2 (15% wheat)	3 (15% wheat + +.1% lys.)	4 (15% wheat + +.2% lys.)	5 (16% wheat)	6 (17% wheat)
No. pens per treatment	3	3	3	3	3	3
No. pigs per pen	16	16	16	16	16	16
Av. int. wt., lb.	55.9	57.0	55.7	55.0	56.8	55.5
Av. final wt., lb.	219.4	220.5	220.8	219.3	219.2	219.5
Av. daily gain, lb.[1]	1.71a	1.53	1.66ab	1.67acd	1.64bd	1.62bc
Feed per lb. gain, lb.	3.44	3.55	3.48	3.39	3.44	3.42
Av. da. feed intake, lb.	5.88	5.43	5.77	5.66	5.64	5.54
Av. adj. backfat, in.	1.28	1.25	1.27	1.24	1.23	1.22

[1] Any two means without a common superscript differ significantly ($P < .05$).

Feedlot Performance, Probe Backfat Thickness And Carcass Merit For Purebred And 2-Breed Cross Pigs

R. K. Johnson, I. T. Omtvedt, R. R. Wilson and L. E. Walters

This study included 206 purebred and 409 2-breed cross barrows and gilts of the Duroc, Hampshire and Yorkshire breeds. Growth rate data on all pigs, probe backfat thickness from 301 gilts and slaughter data on 96 barrows were analyzed to compare crossbreds to 2-breed cross pigs. Crossbred pigs gained 0.14 lb. per day faster from weaning to 220 lbs. and required 11 days less to reach 220 lbs. The overall differences in feed efficiency and probe backfat between crossbreds and purebreds were not significant, although crosses involving Durocs were less fat than the average of the breeds making up the cross. Although more comparisons are needed before one can make definite conclusions regarding differences among specific crosses, the preliminary results tend to support the general

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conclusion that crossbreeding does not greatly improve carcass merit over the average of the two breeds making up the cross.

Introduction

Traits such as growth rate, backfat thickness and carcass traits are moderately to highly heritable and are not expected to exhibit much heterosis. Distinct breed differences for these traits are known, but information on specific crossing sequences or how to best combine breeds in a crossbreeding program are not known.

To obtain information on these questions, project 1444 was initiated to evaluate the general combining ability of Durocs, Hampshires and Yorkshires in 2-breed and 3-breed crosses. This paper reports feedlot performance and carcass merit data from pigs farrowed in 1971 spring in the first phase of this study where purebred and 2-breed cross pigs are compared. Because the data includes only one season and the number of animals within any breed group are rather limited, this paper will deal with only the overall differences between purebreds and crossbreds. The same breeding structure has been repeated and the additional data along with those reported here should provide sufficient numbers to compare differences between reciprocal crosses and to evaluate the influence of maternal effects in crossing sequences.

Experimental Procedure

The data for this study includes the barrows and gilts produced in the Fort Reno swine breeding herd in the 1971 farrowing season. A total of 409 crossbred and 206 purebred pigs from 89 litters are included. The litters were produced by mating 6 boars from each of the Duroc, Hampshire and Yorkshire breeds to 2 gilts from his own breed and 2 gilts from each of the other 2 breeds.

All pigs were weaned at 6 weeks and moved to the confinement finishing facilities when they were 8 weeks old. The pigs were self-fed by breed in groups of about 16 pigs per pen until they reached 220 lbs. When the pigs were weighed off test, probe backfat measurements were made on each gilt.

At the time the pigs were weighed off test a random sample of 96 barrows were slaughtered and carcass cutout obtained at the University Meat Laboratory. In addition to standard carcass measurements, meat quality was evaluated by scoring the loins for marbling and firmness.

Results

The comparison of purebred and 2-breed cross pigs for feedlot per-

Table 1. Feedlot Performance and Probe Backfat Thickness for Purebred and 2-Breed Cross Pigs[1]

Breed	No. Pigs	Daily Grain Lbs.	Days to 220 Lbs.	Feed/lb. Grain	Probe Backfat for Gilts in.
Durocs	69	1.39[a]	181.7[a]	3.16[a]	1.47[a]
Hamps	70	1.33[a]	185.5[a]	3.14[a]	1.20[b]
Yorks	67	1.36[a]	186.1[a]	2.82[a]	1.22[b]
Duroc-Hamp Cross	132	1.48[b]	173.9[b]	3.04[a]	1.24[b]
Duroc-York Cross	153	1.51[b]	171.6[b]	2.94[a]	1.31[c]
Hamp-York Cross	124	1.49[b]	174.1[b]	3.03[a]	1.28[bc]
Purebreds[2]	206	1.36[a]	184.4[a]	3.04[a]	1.30[a]
Crossbreds[2]	409	1.50[b]	173.2[b]	3.00[a]	1.27[a]

[1]Means in same column for a trait with different superscripts are significantly different from each other ($P \leq .05$).
[2]Superscripts on overall means compare only crossbred and purebred overall means.

formance and probe backfat thickness is shown in Table 1. Crossbred pigs gained 0.14 lb. per day faster from weaning to 220 lbs. than purebreds and required 11 days less to reach 220 lbs. All crossbred groups gained significantly faster than did the average of the purebreds which made up the cross.

The differences in feed efficiency were not significant. Overall, crossbred pigs took 0.04 lbs. less feed per pound of gain than purebreds, however the Duroc-Hampshire cross required 0.11 lbs. less per pound of gain than the average for purebred Durocs and Hampshires. More data on feed efficiency are needed before any conclusions can be made.

Even though crossbred pigs averaged only 0.03 in. less backfat than purebreds, rather large differences were noted for certain crosses. Duroc-Hampshire crossbred pigs had significantly less backfat than the average of Duroc and Hampshire purebreds. Although non-significant, Hampshire-Yorkshire crossbred pigs had 0.07 in. more backfat than the average of purebred Hampshire and Yorkshires.

The data for the 96 purebred and crossbred pigs slaughtered are presented in Table 2. The numbers within any breed group are limited and consequently definite conclusions cannot be made. Carcass traits are generally moderate to highly heritable and would be expected to exhibit little heterosis and these data generally tend to support this conclusion. Significant heterosis was obtained for Duroc-Hampshire crossbred barrows for loin eye area, ham-loin index, marbling score and firmness score. There was also some evidence for positive heterosis for the Duroc-Yorkshire cross for percent lean cuts of live weight and marbling score, however Hampshire-Yorkshire crosses tended to have negative heterosis for percent lean of live weight and both quality scores. The small numbers

Table 2. Carcass Merit Comparisons of Purebred and 2-Breed Cross Barrows[1]

Breed	No. Car-casses	Length, in.	Backfat in.	Loin Area (in²)	Ham-Loin Index	% Lean Live Weight	Quality: Marb-ling[3]	Quality: Firm-ness[4]
Durocs	12	30.0[a]	1.27[a]	4.83[a]	94.1[a]	39.6[a]	5.9[a]	6.3[a]
Hamps	12	30.7[b]	1.10[b]	4.84[a]	98.2[a]	41.1[b]	2.8[b]	3.5[b]
Yorks	12	30.7[b]	1.30[a]	4.63[a]	88.7[a]	39.1[c]	4.7[c]	5.8[a]
Duroc-Hamp Cross	20	30.4[ab]	1.20[c]	5.20[b]	101.6[b]	41.0[b]	5.4[ac]	5.6[a]
Duroc-York Cross	20	30.8[bc]	1.26[ac]	4.76[a]	93.2[a]	40.2[d]	5.8[a]	6.1[a]
Hamp-York Cross	20	30.7[bc]	1.26[ac]	4.70[a]	90.2[a]	39.6[a]	3.2[b]	4.0[b]
Purebreds[2]	36	30.5[a]	1.22[a]	4.77[a]	93.7[a]	39.9[a]	4.5[a]	5.2[a]
Crossbreds[2]	60	30.6[a]	1.24[a]	4.89[a]	95.0[a]	40.3[b]	4.8[b]	5.2[a]

[1] Means for a trait in the same column with different superscripts are significantly different ($P \leq .05$).
[2] Superscripts on overall means apply only to comparison of overall crossbred and purebred means.
[3] Scored on a scale of 1 to 7 (1 = devoid; 5 = average; 7 = abundant).
[4] Scored on a scale of 1 to 7 (1 = very soft; 5 = average; 7 = very firm).

and the failure of crosses to respond alike necessitates the collection of more data. Additional data are also needed in order to evaluate differences between reciprocal crosses.

In general these data indicate that crossbreds pigs gained faster in the feedlot than purebreds and exhibited significant heterosis for growth rate. A small amount of heterosis was obtained for certain carcass traits, however these data generally tend to support the conclusion that crossbreeding does not greatly improve carcass merit over the average of the parental breeds.

Comparison Of Purebred Gilts With Purebred And Crossbred Litters From Early Embryo Development Through Weaning

R. K. Johnson, I. T. Omtvedt, R. R. Wilson and S. D. Welty

Story in Brief

This study was initiated to evaluate the performance of purebred Duroc, Hampshire and Yorkshire gilts when mated to a boar of the same breed as compared to when mated to a boar of one of the other two breeds. A total of 299 matings were made in the fall of 1970 and the spring of 1971. One month after breeding 119 gilts were slaughtered and their reproductive tracts evaluated to determine ovulation rate and early embryo development. The remaining 180 gilts were carried full term to evaluate productivity of sows with purebred and 2-breed cross litters.

Although the differences were not large, the purebred gilts with crossbred embryos consistently averaged more normal embryos and a higher percentage of ova shed represented as live embryos than did purebred gilts with purebred embryos. Differences in 30-day embryo size between purebreds and crossbreds for any breed of gilt were not significant. Purebred gilts with rossbred litters averaged more pigs per litter and heavier litter weights at birth, 21 and 42 days than did purebred gilts raising purebred litters. Pig weight differences between purebreds and crossbreds for each of these periods were not significant. The survival rate from birth to weaning was 7.4 percent higher for crossbred litters than for purebred litters. These data indicated that using a boar of a different breed was more of an advantage for purebred Duroc and Hampshire gilts than for Yorkshire gilts.

Introduction

Approximately 90 percent of the pigs marketed in the U.S. today are of crossbred origin. Research results have shown that sow productivity traits yield the greatest response to crossbreeding. However breeding programs that will yield maximum performance from crossing are un-

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In cooperation with Agricultural Research Service, Animal Science Research Division, USDA.

available. In an effort to evaluate the response expected from crossbreeding using modern-type breeding stock, project 1444 was initiated to evaluate the combining ability of the Duroc, Hampshire and Yorkshire breeds in 2-breed and 3-breed crosses. Three purebred herds were established at the Experimental Swine Farm at Stillwater to provide the seedstock for this project. This paper reports the reproductive and litter performance through weaning of the first phase of this project where purebred females raising purebred litters are compared to purebred females raising crossbred litters.

Experimental Procedure

Data from the swine breeding research herd at Fort Reno were used in this study which included the 1971 spring and fall farrowing seasons. Six boars and 54 gilts from each breed were mated in the fall of 1970 to produce the first season's litters. Each boar was mated to 3 gilts of his own breed and to 3 gilts from each of the other two breeds. Approximately 30 days after breeding one gilt from each mating type for each boar was randomly selected to be slaughtered to evaluate ovulation rates and early embryo development. The other 2 gilts from each mating type for each boar were carried full term and permitted to farrow. During the first season this system resulted in 45 gilts slaughtered for reproductive tract studies and 89 gilts farrowed. This procedure was again repeated six months later and 74 gilts were slaughtered one month after breeding and 91 were permitted to farrow. Approximately one-half of the females which farrowed during the second season were sows and their records were adjusted over all breed groups to a gilt equivalent basis with a least squares additive correction factor. Pigs were not given access to creep feed until after the 21-day weights were obtained.

This report includes the ovulation, embryo and birth data for both seasons, but litter records covering the period from birth to weaning were available only for the 1971 spring farrowing.

Results

The data for number and size of embryos are presented in table 1. A total of 42 Duroc gilts, 40 Hampshire gilts and 37 Yorkshire gilts were slaughtered 30-days postbreeding.

The maximum litter size per sow is established by the number of eggs ovulated per sow. Ovulation rate is measured by the number of corpora lutea (CL) found on the ovaries of the gilts at slaughter. Using a boar of a different breed should not influence ovulation rate of a gilt, thus all purebred gilts of a breed can be combined to make breed comparisons in ovulation rate. Yorkshire and Duroc gilts both averaged 13.8 CL per gilt which was significantly greater than the 12.1 CL per gilt for Hampshires. Although the differences were not large, purebred gilts with crossbred embryos consistently averaged more normal embryos and a higher percentage of the ova shed were represented as live embryos than did purebred gilts with purebred embryos. Yorkshire gilts had smaller embryos than Duroc or Hampshire gilts but differences between purebreds and crossbreds within any breed were not significant.

A total of 89 litters (30 purebred and 59 crossbred) were farrowed in the spring of 1971 and 91 litters (34 purebred and 57 crossbred were farrowed in the fall of 1971. Birth records for these pigs are shown in the bottom portion of Table 1. In all cases the gilts with crossbred litters averaged more pigs per litter and heavier litter weights than did gilts with purebred litters. Although the overall advantage of 0.5 more pigs at birth for crossbreds was not significant, the advantage of 2 lbs. heavier litter weight for crossbred litters was significant.

The litters records through weaning of the gilts farrowed in the spring of 1971 are presented in Table 2. Although litter birth records for this season were not analyzed separately but were analyzed together with the fall 1971 season, the number of pigs born per litter in spring 1971 are included in this table so that meaningful breed comparisons of litter records from birth to weaning can be made. Significant differences favoring crossbred litters were obtained for number of pigs at 21 and 42 days as well as for litter weight at 21 and 42 days. However, it should be noted that although litter size and weights at birth and weaning favored the

Table 1. Thirty-Day Postbreeding Embryo Development and Birth Litter Records of Purebred Gilts with Purebred Litters Compared To Purebred Gilts with Crossbred Litters[1]

	Duroc Gilts[3]		Hamp Gilts[3]		York Gilts[3]		Overall[2,3]	
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross
No. slaughtered	13	29	14	26	12	25	39	80
No. CL/gilt	14.3[a]	13.5[a]	11.6[a]	12.3[a]	13.8[a]	13.8[a]	13.2[a]	13.2[a]
Embryos/gilt	10.6[a]	11.0[a]	8.6[a]	9.9[a]	11.4[a]	11.6[a]	10.2[a]	10.8[a]
Survival, %	74.2[a]	81.4[a]	74.5[a]	82.4[a]	83.9[a]	84.4[a]	77.6[a]	82.7[a]
Embryos size, mm.	24.6[a]	25.4[a]	26.2[a]	25.3[a]	23.4[a]	24.0[a]	24.6[a]	24.8[a]
No. farrowed	24	38	22	45	18	33	64	116
No. pigs born	9.0[a]	10.3[b]	8.8[a]	9.0[a]	9.4[a]	9.6[a]	9.1[a]	9.6[a]
Litter birth wt.	23.6[a]	26.3[b]	21.0[a]	23.4[b]	20.3[a]	21.0[a]	21.6[a]	23.6[b]
Pig birth wt.	2.70[a]	2.59[a]	2.41[a]	2.63[a]	2.24[a]	2.22[a]	2.45[a]	2.48[a]

[1]Includes winter 1970 and summer 1971 embryo data and spring 1971 and fall 1971 farrowing data.
[2]Each breed group weighted equally.
[3]Means with different superscripts for a trait within any breed of gilt are significantly different from each other (P< .05).

Table 2. Productivity of Purebred Gilts with Purebred Litters Compared to Purebred Gilts with Crossbred Litters from Birth to Weaning[1]

	Duroc Gilts[3]		Hamp Gilts[3]		York Gilts[3]		Overall[2,3]	
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross
No. litters	10	20	7	22	9	17	26	59
No. pigs born	9.1	10.3	8.2	8.9	9.8	10.4		
No. at 21-days	5.9[a]	7.6[b]	4.9[a]	6.5[a]	8.0[a]	8.3[a]	6.3[a]	7.5[b]
Lit. 21-day wt.	55.4[a]	79.6[b]	49.5[a]	68.1[a]	86.5[a]	84.2[a]	63.8[a]	77.3[b]
Pig 21-day wt.	9.16[a]	10.5[a]	10.0[a]	10.2[a]	10.9[a]	10.3[a]	10.0[a]	10.3[a]
No. 42-days	5.6[a]	7.5[b]	4.7[a]	6.4[a]	7.9[a]	8.2[a]	6.1[a]	7.4[b]
Lit. 42-day wt.	132.7[a]	183.7[b]	107.1[a]	151.9[a]	192.3[a]	195.6[a]	144.0[a]	177.1[b]
Pig 42-day wt.	23.6[a]	24.4[a]	21.9[a]	23.3[a]	24.7[a]	24.0[a]	23.4[a]	23.9[a]
% Survival	58.0[a]	74.0[a]	67.3[a]	75.1[a]	82.3[a]	80.8[a]	69.2[a]	76.6[a]

[1]Spring 1971 farrowing only.
[2]Each breed group weighted equally.
[3]Means with different superscripts for a trait within any breed of gilt are significantly different from each other ($P < .05$).

Yorkshire gilts with crossbred litters over the Yorkshire gilts with purebred litters, these differences were relatively small and that most of the advantage contributing to crossbred superiority came from using a boar of another breed on Duroc and Hampshire gilts.

Although crossbreeding involving Yorkshire gilts did not increase survival rate and the overall increase of 7.4 percent for crossbreds over purebreds was not significant, Duroc and Hampshire gilts raised a considerably higher proportion of the pigs farrowed when raising crossbred litters than when raising purebred litters (16 percent for Duroc gilts and 7.7 percent for Hampshire gilts). There were no consistent trends in average pig weights at 21 and 42 days. More data are needed before definite conclusions involving the relative differences in crossbred productivity for the 3 breeds can be made.

Two basic reasons for crossbreeding are to obtain heterosis and to combine the strong points of different breeds. Heterosis is defined as the difference in the average performance of crossbreeds compared to the purebreds which made up the cross. Considerable heterosis was observed for the productivity traits measured in this study. The results also revealed that the breed of sire effect was generally small indicating that the sire breed used was of minor importance. However the breed of dam effect was generally large for all traits evaluated. This would indicate that the dam breed used in a crossbreeding program is of considerable importance for productivity traits. Thus, in order to develop a breeding program that will yield maximum performance from crossing, information on the productivity for specific crosses is needed.

Table 3 shows the average performance for each cross for embryo and birth records. The numbers are too limited to draw any definite conclusions at this point, but quite large differences between certain reciprocal crosses were observed for embryo numbers. For example, Duroc gilts mated to Hampshire boars had 1.3 more normal embryos at 30 days postbreeding than Hampshire gilts mated to Duroc boars.

Virtually no difference in early embryo percent survival existed among the crosses, thus the differences between the reciprocal crosses in number of embryos appears to be primarily a function of differences in ovulation rates of the breeds. Although no significant differences between reciprocal crosses were obtained at this point, there was a tendency for Yorkshire gilts to be superior to the gilts of the other 2 breeds in reciprocal crosses and for Duroc gilts to out-perform Hampshire gilts. When reciprocal crosses were combined (DxH and HxD; DxY and YxD; HxY and YxH) and comparisons among crosses made, pig birth weight was the only trait for which crosses were different. Duroc-Hampshire crossbred pigs were heavier at birth than crosses involving the Duroc-Yorkshire or Hampshire-Yorkshire breeds.

Results of this study indicate that the relative advantage of crossbreeding is highly dependent on the breed of dam involved. Using a boar of a different breed increased litter size and litter weight at farrowing, 21-days and weaning. Crossbreeding increased the productivity of Duroc and Hampshire gilts more than it did Yorkshire gilts.

Table 3. Comparison of all Possible Crosses for Early Embryo[1] Development and Gilt Productivity at Birth[2]

	DxH	HxD	DxY	YxD	HxY	YxH
No. gilts slaughtered	12	11	13	18	12	14
No. embryos/gilt	9.8	11.1	11.3	10.9	11.8	9.9
% Survival	83.8	80.5	83.3	80.9	85.6	81.0
Embryo size, mm.	25.7	26.2	24.5	24.7	23.4	25.0
No. gilts farrowed	23	18	18	20	15	22
Pigs born/litter	8.6	10.3	9.9	10.3	9.3	9.4
Litter birth wt., lb.	22.8	27.5	20.4	25.1	21.7	24.1
Pig birth wt., lb.	2.73	2.68	2.12	2.50	2.33	2.53

[1]Includes winter 1970 and summer 1971 embryo data.
[2]Includes spring 1971 and fall 1971 farrowing data.

Techniques For Rearing Cesarean Section Derived Colostrum Free Piglets

J. A. Coalson, C. V. Maxwell, J. C. Hillier, and E. C. Nelson

Story in Brief

Ninety-one colostrum free piglets (5 replicates) were obtained by cesearean section on the 113 day of gestation, placed into individual sterile incubators and fed 5 times daily a fortified milk diet to 3 weeks of age. Eighty-one piglets were successfully reared to 3 weeks of age for an average survival rate of 90 percent. Average dietary intake at 7, 14, and 21 days were 17, 38 and 49 oz., respectively. Average weight gain for the 3 week period was 9.68 lb. Conversion of dry matter to gain ranged from 0.76 to 1.15 for individual replicates. These results indicate that colostrum free piglets can routinely be obtained and reared by this technique and, as such, make excellent models for studying the nutritional requirements of the young pig.

Introduction

Estimates from various surveys have shown that an appalling percentage (up to 30 percent) of the pigs born alive do not survive until weaning. Most of these deaths occur within the first few days of life, and a large part of the death loss is from weaker pigs which are unable to compete with the larger, stronger pigs in a large litter. It is possible that this high mortality can be decreased by the non-conventional rearing of pigs form birth in a system which would decrease competition among littermates and minimize the possibility of contamination with pathogenic organisms. This type system would also provide excellent facilities to study the effect of both nutritional and environmental factors related to the survival of the baby pig. Furthermore, a system of this type could be used for the routine production of specific pathogen free pigs.

The purpose of this paper is to describe the facilities and techniques used to routinely rear cesarean section derived colostrum free pigs to 3 weeks of age.

Materials and Methods

Ninety-one neonatal piglets (5 replicates), obtained from Hampshire and Yorkshire sows, were used to develop techniques for rearing cesarean section derived pigs to 21 days of age. Each sow was transported to the Clinical Research Laboratory of Veterinary Medicine on the 113th day of gestation and scrubbed with soap and disinfectant. The sow was then physically restrained, indused and anesthesized with halothane, using a partial rebreathing system and face mask.

Standard surgical procedures were followed with every possible precaution taken to reduce contamination of piglets. The pig handlers, in addition to the surgeons, wore sterile gowns, gloves, caps and masks during the surgery and resuscitation period. Upon removal from the uterus, the piglets were placed on sterile towels, membranes removed, mucous cleaned from the mouth and resuscitated by body massage. Mucous was cleaned from the airway by supporting the head of the piglet and swinging in a downward motion. When the piglets were breathing satisfactorily, 2 to 6 min., they were placed directly into a sterile pig isolator for transport to the swine nutrition laboratory. Total time elapsed from removal of the first piglet from the uterus to placing of the piglets in individual isolators was never more than an hour.

Incubator facilities.

The incubators were contained in a room the entrance of which consisted of an air barrier anteroom. The anteroom prrovided facilities to prepare the feeding apparatus and provided an air barrier to reduce outside contamination. Individual disposable cardboard incubators (Figure 1), designed to provide each piglet with dry, heated, filtered and sterilized air, were used to hold the pigs for the 21-day period. The air entering the incubator was sterilized and dehumidified, forced over thermostatically controlled heaters and passed through cotton filters. The air passing out of the incubators into the room was exhausted from the building and was not recycled. The temperature of each incubator was maintained at 95°F for 72 hours, then gradually decreased to 82°F by 2 weeks. A grill platform of wire mesh, covered with diamond shaped rubber matting, was 2.08 inches above the bottom of the incubator and kept the piglet free of its urine and feces (Figure 2). The cardboard incubator including feed trays, wire mesh bottoms and rubber mats, were sterilized in an autoclave (250°F for 30 min.) before being placed in the incubator room.

Diet.

The liquid diet fed the pigs to 21 days of age consisted of fresh whole milk fortified with dried whole milk, minerals and vitamins (Table 1). All ingredients were mixed together, homogenized at a cylinder pressure of 1750 psi, pasturized and stored in milk containers until need-

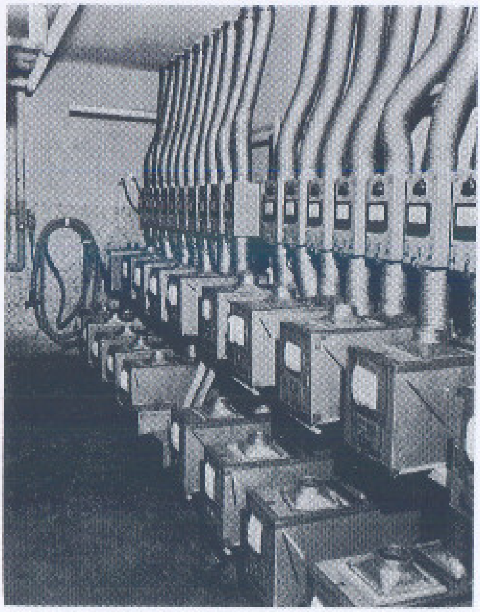

Figure 1. Partial view of incubator room with incubators in place.

Table 1. Comparison of Fortified Milk Diet and Sow's Milk

Percent	Fortified milk diet[1]	Sow's milk[2]
Total solids	21.6	21.2
Protein	6.4	6.1
Fat	5.9	9.6
Carbohydrate	8.0	4.6
Ash	1.3	0.9
Caloric Distribution		
Protein	23	22
Fat	48	59
Carbohydrate	29	19

[1] Prepared by adding to 1 gallon of fresh milk: 1.4 lb. dried whole milk, 5.0 g citric acid, 16.0 mg niacin, 3.0 mg vitamin K, 80 I.U. vitamin D, 7.5 I.U. vitamin E, 272 mg $ZnSO_4 \cdot 7H_2O$, 521 mg $FeSO_4 \cdot 7H_2O$, 120 mg $MnCl_2 \cdot 4H_2O$, 62 $CuSO_4 \cdot 4H_2O$, 2 g $MgSO_4 \cdot 7H_2O$.

[2] From Perrin's data (1954).

ed. The liquid diet was very similar to sow's milk with respect to caloric density and protein content (Table 1).

Feeding regime.

To minimize contamination the technician, upon entering the anteroom, put on a lab coat, rubber boots and sterile surgical gloves before preparing the diet. The liquid diet was stored at 36°F and was heated to 98°F for feeding. Pigs were fed initially within 3 hours of birth and thereafter, at 4 hour intervals, starting at 6:00 a.m. and ending at 10:00 p.m. To feed piglets, the diet contained in a sterile syringe with a 12 gauge needle was injected through a rubber stopper into the metal feeding tray (Figure 2). Each pig was given approximately 1 oz. of diet the first feeding and usually consumed that quantity without any difficulty. The volume fed each pig was increased at each feeding if the previous feeding had been consumed. By this technique, the feeding of pigs appeared to be esstentially on an *ad libitum* basis.

Results and Discussion

Average survival for all 5 replicates was 90 percent and ranged from 83 to 100 percent for each individual replicate (Table 2). Betts, Lamont and Littlewort (1960) reared colostrum deprived hysterectomy pigs under similar hand feeding conditions and reported an overall survival rate of 82.3 percent. A necropsy was performed on each pig that died during the

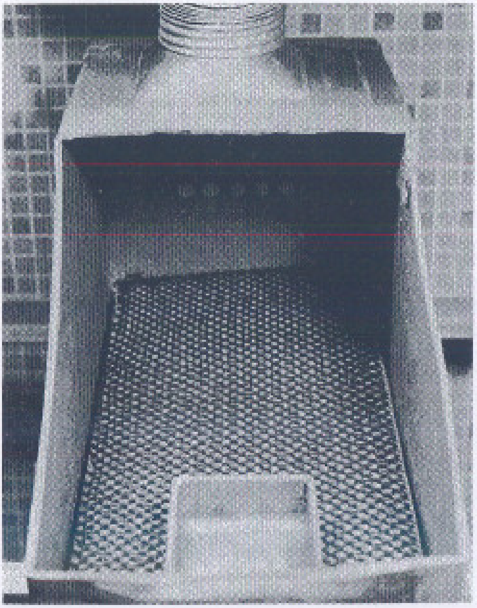

Figure 2. A cut-a-way of an incubator showing feeding tray and wire grill covered with protective matting. (Inside dimensions: 21.5 x 10.5 x 8.3 inches)

Table 2. Survival, Weights and Dietary Efficiency of Colostrum Free Pigs to 21 Days of Age

Replicate No.	No. Pigs	% Survival	Initial Weight (lb)	Final Weight (lb)	lb D.M. / lb gain	Diet Intake 21 days (oz.)
1	24	92	2.86	11.66	0.76	456
2	29	83	2.64	11.44	0.77	466
3	13	100	2.64	13.42	1.00	747
4	11	90	2.64	12.32	0.94	629
5	14	86	2.86	13.64	1.15	852

21 day period and colibacillosis was the usual diagnosis. Most of these deaths occurred during the first 4 days. These survival rates and low bacterial infection rates are unusual in that the feeding trays were not removed or cleaned during the 21 day period. Procedures reported by Young and Underdahl (1953) and Betts, Lamont and Littlewort (1960) involved the use of two sets of feeding trays, one set was soaked in disinfectant and while the second set was used for feeding.

Average dietary intakes for the five replicates of pigs were 17, 38 and 49 oz. at 7, 14 and 21 days, respectively. These volumes roughly indicate how much the young piglet can safely consume under hand feeding conditions. The volumes consumed on the seventh day were below those reported by Lecce (1969) where pigs fed hourly on an automatic feeding device received 25 oz. Dietary intakes on the 14th day were similar to those of Lecce's automatic feeder indicating that maximum dietary intake is greater when fed hourly instead of five times daily, particularly during the first week. Dietary intakes at 14 days were almost twice that reported by Betts, Lamont and Littlewort (1960) where hysterectomy obtained pigs were hand fed 3 times daily.

Total gains for the 21 day period ranged from 8.8 lb. for replicates I and II to 10.78 lb. for replicates III and V (Table 2). This demonstrates the considerable variation obtained when using a hand feeding system. The average gain for the five replicates was 9.68 pounds. These gains are superior to those reported for naturally suckled pigs cited in the literature. This suggest that not only can survival rate be increased by a system of this type but pig weight at 3 weeks can also be increased.

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Sheep

Adaptation of Lambs to Biuret as a Nitrogen Source When Fed High Concentrate Rations

R. R. Johnson and E. T. Clemens

Story in Brief

It had previously been shown in this laboratory that rumen microorganisms in both sheep and cattle required considerable periods of time varying from 20 to 40 days of exposure to biuret in the feed before significant ability to utilize biuret as a source of nitrogen could be shown.

In the experiment reported here, the ability of the microorganisms to adapt to biuret when the animals were fed high concentrate rations was studied. In contrast to the relatively long adaption period required when biuret was fed with high roughage rations, with rations containing 60 percent concentrate, adaptation was complete by 10 days after the start of biuret feeding. Similar to the results with high roughage rations, however, when biuret was removed from the high concentrate ration the biuretolytic activity was lost by 4 days after removal.

Introduction

Biuret is being tested as a source of supplemental nitrogen to ruminants, primarily in relation to protein supplements being fed to ruminants on low quality roughage regimes. In experiments conducted at Oklahoma, we have shown that a period varying from 20 to over 40 days of exposure to the biuret in the supplement may be required before the rumen microorganisms can fully utilize the biuret or can break it down to a useful form of nitrogen (biuretolytic activity). This period required to develop biuretolytic activity on high roughage rations appears to be related to the level of natural protein in the rations as well as to the level of concentrate that might be added to the roughage. Biuret has also been proposed as a source of supplementary nitrogen for ruminants consuming high concentrate rations. Therefore, the objectives of the present experiment were to investigate the adaptation to biuret as a source of nitrogen by lambs consuming high concentrate rations.

Materials and Methods

Trial 1. Eight rumen fistulated sheep were divided into four lots of two animals each and fed the rations shown in Table 1. These rations consisted of approximately 60 percent concentrate type feeds and cottonseed meal was compared to urea, biuret and a combination of urea and biuret as nitrogen sources. The rations were fed free choice daily for a period of 75 days. On days 10, 17, 31, 45, 59 and 75 after the initiation of biuret feeding, the ability of rumen microorganism to hydrolyze biuret in a laboratory flask (biuretolytic activity) was determined on all lambs on all rations. At the end of the 75 days, the two lambs on each of the biuret and the urea + biuret rations (rations 2 and 4) were given ration 1 which had no biuret and the biuretolytic activity was measured on days 1, 2, 4 and 7 after the switchover.

Trial 2. Twenty four spring lambs from the station flock were divided into four groups of 6 lambs each and fed the same rations as

Table 1. Composition of Rations for High Concentrate Trial 1 and 2

Ingredient	Percentage composition, as is basis			
	1 CSM[1]	2 U	3 B	4 U+B
Ground corn	40.3	54.1	53.5	53.7
Cottonseed hulls	38.0	38.0	38.0	38.0
Molasses	5.0	5.0	5.0	5.0
Cottonseed meal	15.7	–	–	–
Urea	–	1.83	–	0.92
Biuret, pure	–	–	2.35	1.18
Limestone	0.4	0.4	0.5	0.5
Dicalcium phosphate	–	0.07	0.05	0.1
T.M. salt	0.6	0.6	0.6	0.6
Vit A & D	+	+	+	+

[1] Abbreviations Refer to Cottonseed meal-CSM, U-Urea, B-Biuret.

shown in Table 1. This trial was designed as both a growth and performance trial as well as a digestion study. Seven day feces collection periods were conducted starting at days 20 and 60 after the initiation of feeding for purposes of determining digestibility of the ration constituents. Rations were fed free choice and the animals were weighed at two week intervals.

Results and Disscussion

Figure 1 illustrates the biuretolytic activity of the rumen contents from the fistulated sheep fed these rations over the entire experiment. A

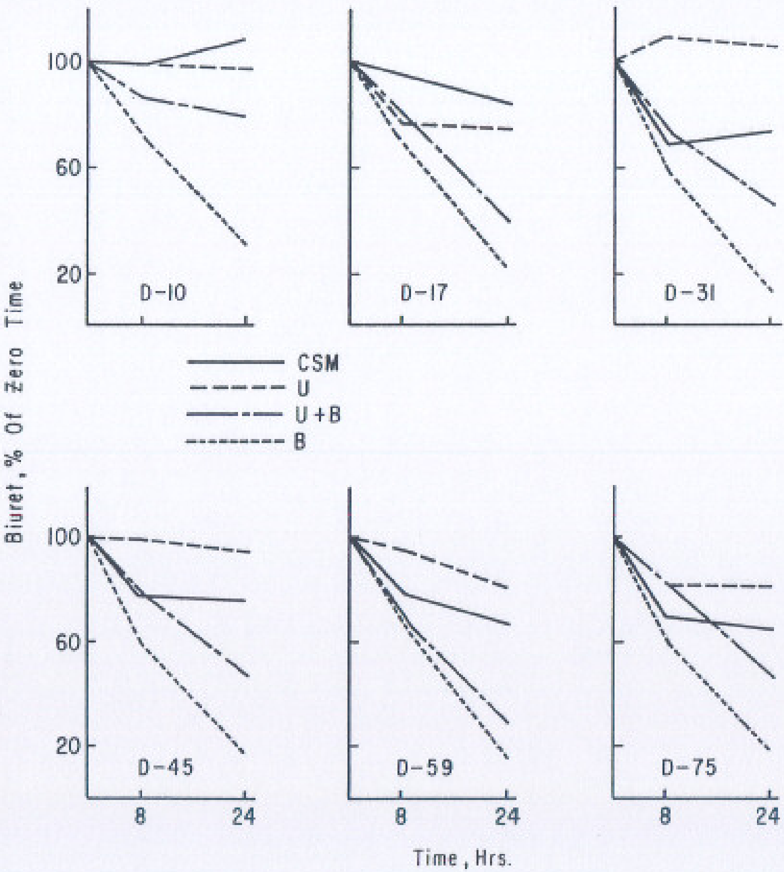

Figure 1. Biuretolytic activity of rumen contents for animals fed high concentrate rations. Each line represents average of two animals.

rapidly declining line indicates significant biuretolytic activity or the ability to break this form of nitrogen down to a useful form. It can be seen that on day 10 the rumen microorganisms in the animals fed the biuret ration had already adapted to this nitrogen source and there was little improvement for the remainder of the experiment in their ability to hydrolyze the biuret. The animals consuming the urea plus biuret ration were not fully adapted until day 17 and at no time was their adaptation equal that shown by the animals consuming the biuret ration.

Although there were some traces of biuretolytic activity in rumen contents from the animals on the other two rations which did not contain biuret, these are considered to be artifacts since most of this activity was in the first 8 hours of incubation, with little activity shown between 8 and 24 hours. When the biuret was removed from the ration for those animals that had been adapted to the biuret, the loss of biuretolytic activity was very rapid as shown in Figure 2. Biuretolytic activity had essentially disappeared by two days after the removal. This is very simliar to the loss of biuretolytic activity shown in previous studies when high roughage rations were being utilized.

Table 2 presents the performance results for the lambs fed the high concentrate rations supplemented with biuret. During the course of this trial, considerable difficulty was encountered with several of the lambs

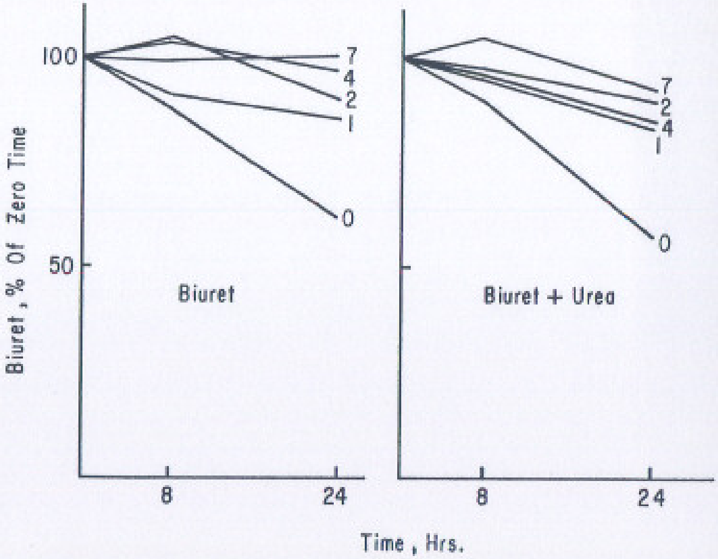

Figure 2. Disappearance of biuretolytic activity in vitro in Trial 1 following removal of biuret from the ration.

and five lambs had to be removed from the experiment either through death or other causes. Therefore, the performance data should be considered in this light. The fastest rate of gain was shown by the animals consuming biuret supplemented rations followed closely by those on the cottonseed meal ration. Those on the urea and biuret or urea were still lower. Since only three animals finished the experiment on the cottonseed meal control ration, it is difficult to draw any conclusions from these results. The biuret ration was consumed as well as any of the other rations and apparently better than some, although feed efficiency was actually best for the control ration containing cottonseed meal. Little more can be said about these results without repeating these experiments.

The apparent digestibilities determined for these animals for the two periods starting at day 20 and day 60 are shown in Table 3. There

Table 2. Performance of Lambs On High Concentrate Rations (Trial 2)

	1 CSM	2 U	3 B	4 U+B
No. animals	3[1]	5	6	5
Initial wt. lb.,	43.8	52.1	49.7	51.3
Final wt., lb.	90.6	95.9	100.3	95.5
Ave., daily gain, lb.	0.312	0.279	0.323	0.285
Ave. daily feed, lb	2.26	2.58	2.76	2.52
Feed per lb. gain, lb.	7.24	9.25	8.54	8.84

[1] Three of the heavier lambs from this group were removed from this treatment for health reasons which probably affected th average.

Table 3. Apparent Coefficients of Digestibility-High Concentrate-Trial 2

	Ration			
Period[1]	1 CSM	2 U	3 B	4 U+B
	Dry matter digestibility, %			
1 (20)	60.5	56.7	52.2	54.0
2 (60)	64.5	62.1	58.5	59.4
	Organic matter digestibility, %			
1 (20)	60.1	56.7	52.1	53.9
2 (60)	64.3	61.7	58.3	59.9
	Cellulose digestibility, %			
1 (20)	22.9	17.2	10.7	24.8
2 (60)	42.6	12.3	19.9	11.1
	Nitrogen digestibility, %			
1 (20)	52.8	58.5	54.3	54.9
2 (60)	56.7	65.4	61.8	64.0

[1] Period effect significant ($P < .05$ or less) for all rations for DMD, OMD and ND. Periods refer to 7 day collection periods starting 20 and 60 days after initiating study.

was an apparent increase in digestibility of dry matter and organic matter from day 20 to day 60 but this was not associated with nitrogen source since it occurred in all rations. Cellulose digestibility was extremely low in all cases. Although nitrogen digestibilities were not greatly different in the early period, these values appeared to be greater for the rations containing non protein nitrogen sources during the last period. This may be an indication of an adpation phenomena toward the utilization of non protein nitrogen.

Conclusions

Adaptation to biuret by the microorganisms in the rumen of sheep occurs much more rapidly on the high concentrate rations tested here than on the high roughage rations tested earlier. Nevertheless, the adaptation was lost just as rapidly as with the high roughage ration when biuret was removed from the ration. The utilization of biuret in performance studies with ruminants on high concentrate rations should be studied further before drawing any conclusions on this aspect. Further studies are presently underway to determine the effects of different levels of concentrate on the adaptation and utilization of biuret in comparison to other sources of nitrogen.

A Preliminary Evaluation of Some Growth and Carcass Characteristics of 1/4 Finnish Landrace Lambs

L. D. Flinn, M. B. Gould and J. V. Whiteman

Story in Brief

In the spring of 1971 the first replicate of some experimental ewe lambs were born at Fort Reno. These were composed of four different groups which will be evaluated over a 7 year period to compare them for suitability as commercial ewes under Oklahoma conditions. The breeding groups consisted of: (1) ½ Dorset ½ Rambouillet, (2) ¼ Dorset ¾ Rambouillet, (3) ¼ Finnish Landrace-¼ Dorset-½ Rambouillet and (4) ¼ Finnish Landrace-¼ Rambouillet-½ Dorset.

The data on the ewes and their male sibs suggested that the two groups of Finnish Landrace descent had birth weights about one to one and a half pounds lighter than the Dorset X Rambouillet groups. All groups had approximately the same rates of gain up to 70 days of age (.6 lbs./day). Except for the ¼ Dorset ¾ Rambouillet lambs (.58 lbs./day) rates of gain from weaning to market were also very similar (approximately .51 lbs./day).

The average daily gains from birth to market also showed a faster gain of the ¼ Dorset ¾ Rambouillet lambs (.59 lbs./day) as compared to the other three groups (approximately .56 lbs./day).

It was also observed that early death losses (before two weeks of age) were slightly higher (16.2 and 15.9 percent) in the groups with Finnish Landrace breeding than in the Dorset X Rambouillet groups (11.7 and 5.9 percent).

Eight wether lambs from each of groups 1, 3 and 4 were slaughtered at the Oklahoma State University meat lab. The carcass data taken shows preliminary results. It is a comparison on a very few animals to see the effect of the ¼ Finnish Landrace breeding as compared to the ½ Dorset ½ Rambouillet breeding relative to carcass characteristics.

Results on the comparisons of backfat thickness and dressing percent showed the ½ Dorset ½ Rambouillet lambs to be fatter (.32 in.)

In cooperation with Agriculture Research Service, Animal Science Research Division, USDA.

than the ¼ Finnish Landrace lambs (about .28 in.), and they also had a higher dressing percent (50.3 percent as compared to approximately 48.3 percent). There were no large differences between the breed groups when compared on loin eye area (about 2.0 sq. in) or cutability scores (about 43).

Introduction

One of the main areas of the sheep industry that can be vastly improved is in lamb production per ewe. Two main management systems can be employed to achieve this end: i.e., increase lamb crop percent at each lambing or increase the number of lambings per ewe per year. To determine what breed of ewe is most productive with each system, a long range program was initiated in 1970 at the Fort Reno Livestock Station. The breed crosses to be tested are ½ Dorset ½ Rambouillet, ¼ Dorset ¾ Rambouillet, ¼ Finnish Landrace-¼ Dorset-½ Rambouillet and ¼ Finnish Landrace-¼ Rambouillet-½ Dorset (Table 1).

The Rambouillet was used in this program because it is an out of season breeding sheep, and one of the most widely used western ewes. The Dorset was included because it also is an out of season breeding sheep. Previous research at Fort Reno has shown that the Dorset X Rambouillet ewe was superior to the straightbred Dorset or straightbred Rambouillet on the basis of spring breeding reproductive rate and for twice yearly lambing programs. The Finnish Landrace breed (Finnsheep) is a medium size sheep somewhat deficient in wool production (a coarse wool) and muscling, but is well known for its outstanding prolificacy (often 4-5 lambs in a litter). For the latter reason Finnish Landrace breeding was included in the study. These preliminary results summarize comparisons of the breed groups for birth weights, lamb growth performance, lamb mortality and a few major carcass characteristics. The program is not far enough along to observe these traits on the offspring of the test ewes, therefore, the data in this report is on the ewes themselves and their male sibs.

Materials and Methods

Between 1970 and 1972 planned matings will be made to produce the desired groups of ewes for evaluation. The performance as lambs (of the desired breed crosses that were born in the spring of 1971) were evaluated for this report. There were 71, 55, 74 and 67 lambs in the groups one to four, respectively, as shown in Table 1.

Management practices were the same for all groups of lambs. Lambs were born in the lot and were placed in lambing pens with their mother

Table 1. The Lamb Groups and Their Breed Components with Numbers and Early Death Losses[1] for Each Group

Group No.	Breed Components	No. of Lambs Born	Early Death Losses (%)[1]
1	½ Dorset, ½ Rambouillet	77	11.7
2	¼ Dorset, ¾ Rambouillet	51	5.9
3	¼ Finnish Landrace, ¼ Dorset, ½ Rambouillet	74	16.2
4	¼ Finnish Landrace, ¼ Rambouillet, ½ Dorset	67	14.9

[1] Death before 2 weeks of age.

for 3 to 4 days. At this time lamb data was collected. All lambs had access to a creep feed. The creep feed consisted of five percent molasses, 55 percent cracked milo, ten percent soybean meal and 30 percent ground alfalfa hay.

Starting when the oldest lambs reached 30 pounds the lambs were all weighed biweekly. The lambs were weaned at approximately ten weeks of age and placed in a drylot feed area at the Fort Reno station. When the youngest lambs reached twelve weeks of age the soybean meal was removed from the creep ration and replaced with ground alfalfa hay. Due to the problem of internal parasites in springborn lambs, they were never allowed out of the drylot area until final removal.

The ewe lambs that weighed 75 pounds or over on the biweekly weighings were removed from the drylot and put on a clean pasture with no extra feed. They were bred at 7 months of age to compare their rates of sexual maturity since this is the first reproductive trait that these ewes will be compared for in the long range project. The wethers were carried up to 95 pounds and shipped to market. The last of the wether lambs were used for the carcass data given in this study.

Results and Discussion

Death Losses

Death losses on the spring born lambs have been separated into two divisions; early death losses (before two weeks of age) and lambs that died between two weeks of age and market. Any deaths that occurred between 2 weeks of age and market were contributed to chance and not breeding therefore only death losses were reported here. The two Dorset X Rambouillet groups had early death loss percentages of 11.7 and 5.9 while the Finnsheep groups had 16.2 percent and 14.9 percent early death losses. From these preliminary results (Table 1) it would appear that the lambs with Finnish Landrace breeding had greater death losses than the Dorset X Rambouillet sheep.

Lamb Growth Performance

The lambs from each group were evaluated on growth performance by comparing them for birth weight, rate of gain from birth to weaning, post weaning rate of gain and average daily gain from birth to market (Table 2).

Forty-three of the wether lambs were sold for nutrition work at weaning time and were not used for tabulating average daily gain from birth to market. Also, the ewe lambs were taken out of the drylot at about 75 pounds and, therefore, their post weaning rate of gain and average daily gain figures were only calculated up to about 75 pounds.

The averages for birth weights showed that the ¼ Finn lambs were lighter at birth (8.8 pounds and 8.0 pounds) as compared to the Dorset X Rambouillet groups (9.2 pounds and 9.6 pounds). Rates of gain from birth to 70 days of age were similar for all four groups. The groups containing Finn breeding compared favorably with the ½ Dorset ½ Rambouillet group on rates of gain and average daily gain. However, group 2 (¼ Dorset ¾ Rambouillet) had a higher rate of gain from 70 days to market (.58 lbs./day vs. .51 lbs./day, .52 lbs./day and .49 lbs./day) and a higher average daily gain (.59 lbs./day vs. .56 lbs./day, .57 lbs./day and .54 lbs./day) than the other three groups. Other work at Fort Reno and elsewhere has sometimes shown Rambouillet lambs to be faster gaining lambs than Dorsets, and these results agree with those observations.

Table 2. Birth Weights and Mean Growth Performance of the Spring-born Lambs

Measurement	Mean			
	1/2 D, 1/2 R	1/4 D, 3/4 R	1/4 F, 1/4 D, 1/2 R	1/4 F, 1/4 R, 1/2 D
Birth weight	9.2	9.6	8.8	8.0
Rate of gain up to 70 days	.60	.59	.61	.59
Rate of gain from 70 days to market (lbs./day)[1,2]	.51	.58	.52	.49
Average daily gain from birth to market (lbs./day)	.56	.59	.57	.54
No. of lambs used to calculate average daily gain[2]	54	29	55	50

[1] Ewes lambs were pulled out of drylot at 75 pounds for use in flock.
[2] 43 wethers were sold at weaning time.

Carcass Characteristics

Eight wethers from each of groups 1, 3 and 4 were studied for major carcass characteristics. They were cut and evaluated on chilled carcass weight, loin eye area, backfat thickness, quality grade, leg conformation grade, cutability and dressing percent as shown in Table 3. These wethers were the last of the spring lamb crop to be taken from the drylot.

There were no great differences in loin eye area or cutability, but the groups with Finn breeding did grade lower on quality grades and leg conformation grades. They were also a little lower on dressing percent and chilled carcass weight. Figures on back fat thickness showed that the ½ Dorset ½ Rambouillet lambs were fatter than the groups with Finn breeding (.32 in., as compared to .27 in., and .29 in.).

Table 3. Mean Comparisons for Slaughter Measurements

Measurement	Mean 1/2 Dorset 1/2 Rambouillet	Mean 1/4 Finn 1/4 Dorset 1/2 Rambouillet	Mean 1/4 Finn 1/4 Rambouillet 1/2 Dorset
Number of lambs	8	8	8
Live wt. at Ft. Reno (lbs.)	98.8	96.4	98.4
Chilled carcass wt. (lbs.)	49.7	46.0	47.9
Dressing percent	50.3	47.9	48.8
Cutability	42.8	43.0	43.5
Carcass quality grade[1]	12.6	11.5	12.1
Leg conformation grade[1]	13.3	11.4	12.8
Loin eye area (sq. in.)	2.08	1.90	2.06
Backfat thickness (in.)	.32	.27	.29

[1] Grade code is on a scale of 1 to 15, 11 being average choice, 12 high choice and 13 low prime.

Dairy Nutrition

Methods of Processing Sorghum Grain for Lactating Dairy Cows

L. J. Bush, B. J. Steevens, K. E. Rauch and R. M. Alexander

Story In Brief

Sorghum grain is widely used in the Southwest as the major component in concentrate mixtures for dairy cattle. Consequently, it is important to know which method of processing this grain results in the greatest improvement in nutrient value. Information derived from studies with fattening beef cattle is not directly applicable because of some rather unique problems pertaining to lactating cows.

Three separate trials with lactating cows have been completed. The purpose of one trial was to quantify the relationship between particle size of ground sorghum grain and production of dairy cows. In the other trials, different processing treatments of grain in addition to fine grinding were compared with fine grinding only for dairy rations. Information on rumen fluid characteristics and nutrient digestibility was obtained to aid in interpretation of the results.

In all trials, cows readily consumed the concentrate mixtures with very finely ground grain, except for a day or two after being changed from one ration to another. There was small, but nonetheless consistent, improvement in starch digestibility in favor of the ration with very finely ground grain as compared to rations with grain medium or coarsely ground. Molar percentages of rumen VFA were similar in cows on all rations where these data were obtained, and the ratios of acetic to propionic acid were well within the range known to be commensurate with production of milk with normal fat percentage. Total concentration of rumen VFA at 2, 4 and 6 hours after feeding increased as particle size of grain in the ration decreased.

Milk yield of cows fed very finely ground sorghum grain was greater than that of cows fed medium or coarsely ground grain, with an apparently linear relationship between particle size of the ground grain and milk production response. Fineness of grinding had no effect on percentage of milk fat or total solids.

Dry heating and steaming, or simply steaming the grain in addition to very fine grinding did not improve its feeding value in comparison

to fine grinding only. Pressure cooking and expanding sorghum grain followed by very fine grinding did not improve its value for lactating cows compared to very fine grinding only. There is a need for further research to determine whether some of the newer processing methods might be equal or superior to fine grinding of sorghum grain under conditions where particle size is allowed to vary.

Introduction

Early studies (Fitch and Wolberg, 1934; Darnell and Copeland, 1936; Atkenson and Beck, 1942) established the importance of grinding sorghum grain as opposed to feeding whole grain; however, no critical studies have been conducted heretofore to quantify the relationship between particle size of ground sorghum grain and production responses of dairy cows. With adoption of a method (Ensor *et al.*, 1970) whereby the particle size of ground grain is defined in a standardized manner, meaningful comparisons of results from different studies can now be made.

Experiments comparing different processing treatments of grain for dairy cows are very limited. Fountaine and Bartley (1962) found that steam rolled grain was superior to dry rolled grain in terms of milk yield, but not equal to ground and pelleted grain. Brown *et al.* (1970) observed no difference between steaming, followed by rolling in a conventional manner, and pelleting different proportions of sorghum grain and barley in terms of milk yield, percentage of fat and non-fat solids, and digestibility of various nutrient components.

There is considerable evidence from studies with beef cattle that "fine" grinding (1/8" screen) of sorghum grain improves its digestibility over that obtained with dry rolling or coarse grinding (Smith, *et al.* 1949; Smith and Parrish, 1952; Newson *et al.*, 1968; Totusek, 1969; White *et al.*, 1969). Further, improved feed efficiency was noted by White *et al.* (1969) when very finely ground grain (i.e., ground with 1/16" screen) was compared to finely ground grain for fattening beef steers. Significant increases in dry matter digestibility due to steam flaking, reconstituting, or high-moisture harvesting as compared to coarse grinding or dry rolling, have been observed (McGinty *et al.*, 1967; Husted *et al.*, 1968; Buchanan-Smith *et al.*, 1968). McNeill *et al.* (1970) found that the extent of ruminal digestion of starch in sorghum grain was highly dependent upon the method of processing, with values as follows: dry ground (5/16" screen), 42 percent; reconstituted and ground (5/16" screen), 67 percent; steam flaked, 83 percent; and micronized, 43 percent. It would be logical to expect these different processing treatments to have the same effect on the digestibility of grain by dairy cows as has been observed with beef steers, although the ultimate impact on lactation performance cannot be predicted with confidence.

The main object of these trials was to determine the effect of different methods of processing sorghum grain on production responses of dairy cows. Information on rumen fluid characteristics and nutrient digestibility was obtained simultaneously to aid in interpretation of the results.

Materials and Methods

Three separate trials with lactating cows have been completed. One of these dealt with defining the relationship between particle size of ground sorghum grain and production of dairy cows. In the other two trials, different treatments of the grain in addition to fine grinding were compared with very fine grinding only for dairy rations. Some general observations in this report also will apply to a fourth trial now in progress.

Trial 1.

In this trial, 36 lactating cows (30 Holsteins and 6 Ayrshires) were used to evaluate the effects of grinding sorghum grain to different degrees of fineness on production responses. A 3 x 3 rotational (Latin square) design was used such that each cow was fed each of three rations in turn according to a pre-determined sequence. Periods in the trial were 6 weeks in duration, with data from the last 4 weeks used for analysis and the first 2 weeks of each period allowed for change-over from one ration to another. Cows were started on the experiment at approximately 8 weeks after calving.

The experimental rations consisted of a 50:50 ratio of alfalfa hay and concentrate mixture (Table 1), with the only variable being the particle size of the ground grain. Yellow endosperm hybrid sorghum grain (NK-222) grown at the Ft. Reno Research Station was used in this particular trial. Since grain comprised 70 percent of the concentrate mixture and equal amounts of concentrate and hay were fed, grain made up 35 percent of the total ration.

An attempt was made to grind the grain in a manner to produce three distinctly different particle size distributions by varying screen size and flow rate through the hammermill. This was accomplished to some extent; however, the particle size of the coarse and medium ground grain were not as edifferent as originally expected (Table 2). The very finely ground grain was virtually powdered in comparison to the coarse or medium ground grain.

Table 1. Composition of Concentrate Mixtures

Item	Trial 1 & 4	2	3
Ingredient			
Sorghum grain	70	75	75
Soybean meal, 44%	10	--	--
Wheat middlings	10	--	--
Wheat bran	--	10	10
Molasses, dried	7	--	--
Molasses, liquid	--	7	7
Cottonseed meal	--	5	5
Beef pulp	1	--	--
Urea	--	1	1
Dicalcium phosphate	1	1	1
Salt, trace mineral	1	1	1
Chemical analysis, air-dry basis			
Dry matter	89.0	90.7	89.4
Protein (N x 6.25)	12.5	14.2	12.5
Ether extract	2.7	3.0	1.8
Starch	58.7	--	--
Non-starch carbohydrate	10.7	--	--
Crude fiber	--	2.7	2.1
Nitrogen-free extract	--	65.7	68.3

Feed allowances were calculated with consideration for body weight, age, and initial milk yield and fat test. Energy requirements indicated by Moe *et al.* (1965) were followed, except that extra allowances were made for first and second lactation cows to permit some additional growth. The allowances were reduced by 10 percent of the initial amount at the beginning of the second and third 6-week periods. Intake of nearly equal amounts of concentrate and hay was accomplished by reducing the total allowance by an appropriate amount if more than 10 percent of either hay or concentrate was refused for two consecutive days. Feeding of the planned allotment of feed was resumed as soon as the cow would consume that amount.

Milk production was recorded twice daily. Samples from four consecutive milkings each week were composited for analysis of total solids and fat percentage. The body weight of each cow was recorded on three consecutive days prior to the experiment and during the last three days of each period.

Apparent digestibility of nutrient components was determined during the latter part of each period with 18 cows by using chromic oxide as an external indicator. Concentration and proportion of rumen volatile fatty acids (VFA) were determined in samples collected from each cow on the last day of each period at 2, 4, and 6 hours after the morning grain feeding.

Table 2. Particle Size of Sorghum Grain[1]

Item	Fineness of grind		
	Very fine	Medium	Coarse
		(microns)	
Geometric mean diameter, D_{gw}	315	584	641
Geometric standard deviation, S_{gw}	2.32	2.36	2.36

[1] Determined by a standard procedure adopted by the American Dairy Science Association (Ref.: Ensor *et al.*, 1970).

Trial 2.

In this trial, 24 Ayrshire cows were used to compare the following methods of processing sorghum grain:

a) fine grinding only,
b) fine grinding + steam heating,
c) fine grinding + steam heating + dry heating.

All of the grain was ground to the same particle size to standardize this factor so that the possible merits of the other treatments independent of particle size could be evaluated. Hammermill screen size was 3/64″. In the steam rolling process, the grain was exposed to steam in a conditioning bin prior to rolling; the temperature of the grain immediately after rolling was 170° F. In addition to steam rolling and grinding, one-third of the grain was dry heated for one hour, usually reaching a temperature over 300° F. Following processing by the different procedures, the grain was mixed with the other ingredients of the concentrate mixture (Table 1) and pelleted with a ⅜″ die.

Cows were started on experiment at approximately 6 weeks after calving. Feed allowances based on body weight and milk yield of each cow were computed according to the upper limit of Morrison's TDN standard. Good quality alfalfa hay was fed in equal proportion to grain. A Latin square design was used so that each cow received each treatment for 6 weeks in a pre-determined sequence. Initial feed allowances were reduced by 10 percent at the end of each 6-week period.

Rumen samples were taken from 18 cows at 3 hours after the evening feeding on the last day of each period for VFA analysis. Milk yield of each cow was recorded twice daily and samples were taken at four consecutive milkings each week for determination of fat, total solids, and protein percentages.

Trial 3.

In this trial, 12 Holstein cows were used in a switchback design to compare the following methods of processing sorghum grain:

a) fine grinding only,
b) fine grinding + pressure cooking and expanding to produce approximately 25 percent gelatinization,[1]
c) fine grinding + pressure cooking and expanding to produce approximately 75 percent gelatinization.[1]

The gelatinization process involved first grinding the grain so that approximately 96 percent passed through a No. 30 U.S.B.S. sieve. Then, in a continuous operation, water and steam were added to attain a maximum temperature of about 270° F. at a moisture content of 20 to 21 percent. The total process time (including moistening, heating by injected steam coupled with mechanical forces, and extrusion through dies to form expanded pellets) was about 20 seconds. Actual cooking time in the temperature range 180 to 270° F. was approximately 10 seconds. The expanded pellets lost most of their excess moisture immediately upon emergence from the dies, and were then further dried in a common pellet dryer. The intermediate or partially gelatinized grain was obtained by subjecting more coarsely ground grain than was used for the completely gelatinized product to the above treatment on the assumption that a larger particle of grain should undergo less gelatinization than a smaller one.

All of the expanded grain as well as grain for the control ration was ground through a 3/64″ screen and afterwards mixed with the other ingredients of the concentrate mixture (Table 1). The concentrate mixture was fed in loose form.

During a 6-week period after calving, the cows adjusted to an unpelleted concentrate mixture fed in equal proportion with alfalfa hay. Feed allowances were calculated on the basis of body weight and milk yield as in the previous trial, and were reduced by 10 percent at the end of each 6-week period. A switchback design for three treatments as described by Lucas (1956) was used; therefore each cow received one of the three treatments during the first period, a second one during the next 6 weeks, and then reverted back to the first treatment again during the final period. Different sequences were used so that each of the rations was fed to the same number of cows during each period.

Trial 4.

Thirty-six lactating cows were used in this trial to obtain additional information on the relationship of particle size of ground sorghum grain

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[1]Expanded grain obtained from Grain Products, Inc., Dodge City, Kansas through the courtesy of Evan W. Williams, Jr.

to milk yield. Data on milk yield and composition, feed intake, and body weight changes were obtained in the same manner as in Trial 1. In addition, steers with abomasal fistulas are being used to obtain information on the site and extent of nutrient digestion when rations contain grain ground to different degrees of fineness.

Results and Discussion

Feed Intake

Intakes of hay and grain by the cows were nearly equal in all three trials, reflecting very few problems with feed consumption. The small amount of hay refused usually consisted of coarse stems or moldy material. In Trial 2, cows fed the dry heated grain tended to consume their allowance of hay more completely for some reason, resulting in slightly higher total dry matter intake by this group. Average dry matter intakes of different rations in Trial 3 were similar and consistent with the visual observation that the cows apparently had no strong preference for the unheated grain over that which had been cooked and expanded. Refusals of grain occured only at the first feeding or two after the animals were switched from one ration to another.

In Trials 1 and 4 where the grain was ground to different degrees of fineness, several cows required one or two days to adjust to the ration with very finely ground grain. Otherwise, the cows readily consumed each of the concentrate mixtures. Intake of the mixture with very finely ground grain simply was not a problem in these trials, and it is apparent that cows need not be fed an exceptionally coarse or bulky concentrate mixture providing the amount and quality of forage in the ration is acceptable.

Digestibility of Rations with Grain Ground to Different Degrees of Fineness.

Apparent digestibility of major components was similar for all three rations (Table 3). Digestibility of starch was of particular interest since it comprised a significant part of the concentrate mixture and was the fraction where differences in digestibility due to grinding the grain to different degrees of fineness could most logically be expected. A high percentage of starch in all three rations was digested, with the values being in the same range as those reported by other workers (Karr *et al.*, 1966; Holmes *et al.*, 1970; McNeill *et al.*, 1970). There was a small, but nonetheless consistent, improvement in starch digestibility in favor of the very finely ground grain as compared to the other two rations. These differences in overall digestibility were consistent with production responses; however, it is recognized that relative changes in the sites of starch digestion in the animal might well be of greater importance than differences in the total amount digested. Work aimed at obtaining information on the relation of particle size of ground grain to site of starch digestion in the animal is in progress at this time.

Rumen VFA Characteristics

Molar percentages of rumen VFA were similar for all rations in both Trial 1 and 2 (Table 4). In Trial 1, the acetic to propionic acid ratio was lower at 2 hours after feeding in the group fed medium ground grain, but overall differences among rations were relatively small without any consistent trend. Moreover, the observed ratios of acetic to propionic acid were well within the range known to be commensurate with production of milk with normal fat percentage (Baumgardt, 1967).

Total concentration of rumen VFA at different times after feeding in Trial 1 increased as the particle size of the sorghum grain decreased. The higher concentration of VFA in samples from the group fed finely

Table 3. Apparent Digestibility of Ration Components

Component	Ration Treatment		
	Coarse	Medium	Very Fine
		%	
Dry matter	67.6	69.5	69.8
Crude protein	65.8	67.1	65.3
Ether extract	61.7	63.6	65.1
Starch	96.4^{ab}	96.3^{a}	98.1^{b}
Non-starch CHO	51.4	54.9	53.6

ab Means with different letters are significantly different ($P < .05$).

Table 4. Molar Percentages of Rumen VFA

Acids	Trial 1 rations[1]			Trial 2 rations[2]		
	Coarse	Medium	Very fine	Ground	Ground and steamed	Ground, steamed and dry heated
Acetic	67	66	67	68	70	70
Propionic	19	20	19	17	16	18
Butyric	13	13	13	14	13	11
Valeric	1	1	1	1	1	1
C_2/C_3	3.4	3.4	3.5	4.0	4.3	3.9

[1] Rumen samples taken at 4 hours after feeding.
[2] Rumen samples at 3 hours after feeding.

ground grain may have been due to more rapid breakdown of starch in this ration by rumen microorganisms. However, the exact mechanism by which this may have affected production response of the cows is not known. Decreases in total feed allowances during the second and third periods of the trial as scheduled were reflected in decreased rumen VFA concentration.

Milk Yield and Composition

Milk yield of cows fed a concentrate mixture with very finely ground sorghum grain was significantly greater than that of cows fed coarsely ground grain. As depicted in Figure 1, there appeared to be a linear relationship between particle size of the ground grain and milk production response. No difference among rations was observed in milk fat or total solids percentage. Overall average fat test was lower than expected and could be attributed to a few individual cows with an exceptionally low test.

The calculated feed allotments were sufficient to sustain an increase in body weight in all treatment groups (Table 5). A small portion of

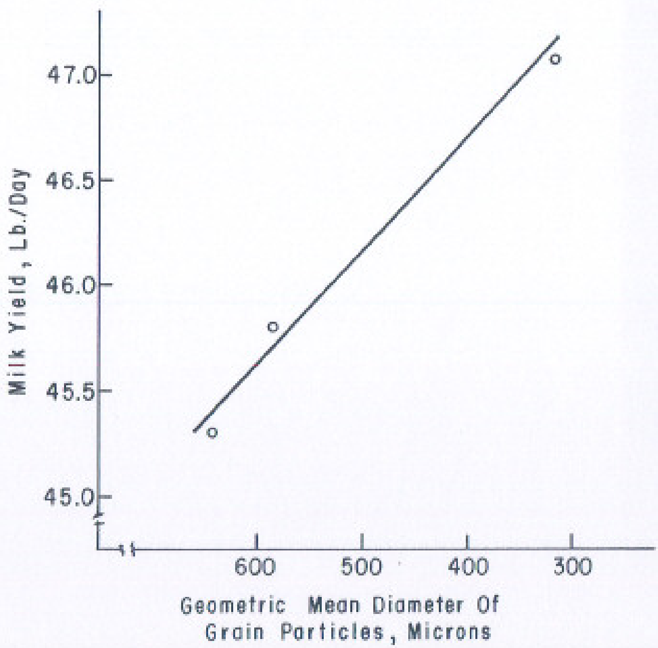

Figure 1. Average daily milk yield in relation to fineness of grinding sorghum grain.

Table 5. Responses of Cows Fed Sorghum Grain Ground to Different Degrees of Fineness

Item	Coarse	Medium	Fine
Feed intake, D. M. basis			
Hay, lb/day	19.6	19.8	19.8
Grain, lb/day	19.6	19.9	19.9
Milk production			
Daily yield, lb	45.3[a]	45.8[ab]	47.1[b]
Fat, %	3.3	3.3	3.3
Total solids, %	11.96	11.96	12.00
Weight change			
Gain per 6-wk, lb	13	26	34

[ab] Means with different letters significantly different ($P \leq .05$).

the gain by cows fed rations with fine or medium ground grain over that by cows fed coarsely ground grain could be accounted for by slightly greater feed consumption by these groups. Assuming an average energy value of body tissue gain in cattle of 3.2 Mcal/lb. (Reid and Robb, 1971), the additional feed consumed would account for approximately 4 lb. of the extra gain by the cows when fed rations with fine or medium ground grain. It was clear that increased milk yield of cows fed the finely ground grain did not reflect greater use of body energy reserves for production. Rather, it appeared that more energy for productive functions was derived from each unit of ration containing finely ground grain.

Dry heating in addition to steaming or simply steaming sorghum grain did not improve its feeding value for lactating cows in comparison to very fine grinding only, under conditions where particle size was held constant (Table 6). Neither yield nor composition of milk was changed by treatments in this trial. Presumably, the heat treatments either did not improve the nutrient value of the grain or any beneficial effects produced thereby were obscured by pelleting the concentrate mixtures. Unfortunately, the heat treatments were not applied in a manner such that dry heating and steaming the grain could be compared independently.

Pressure cooking and expanding sorghum grain to produce partial or nearly complete gelatinization of the starch followed by very fine grinding did not improve its value for lactating dairy cows. Milk yield of cows fed rations containing grain which had been finely ground only was significantly higher than that of those fed the expanded grain (Table 6). However, the milk fat test was slightly lower when cows were fed the ration with unexpanded grain, resulting in nearly the same level of production by all groups when expressed in terms of 4 percent fat-corrected milk. It is possible that cooking of the grain in addition to

Table 6. Feed Consumption and Production by Cows Fed Rations Containing Sorghum Grain Subjected to Different Processing Treatments

Processing method	Dry matter consumed	Milk yield	Fat	Total solids	Weight change
	(lb/day)	(lb)	(%)	(%)	(lb/6wk)
Trial 2					
Finely ground only	29.1	36.3	3.8	12.52	+2.3
Ground & steamed	29.3	36.5	3.7	12.46	—1.7
Ground, steamed & dry heated	29.7	35.8	3.8	12.55	+5.1
Trial 3					
Finely ground only	36.3	52.9[a]	2.9	11.38	+37.3
Ground & part gelatinized	36.1	50.2[b]	3.0	11.74	+23.4
Ground & gelatinized	36.1	51.3[b]	3.0	11.56	+19.0

[ab] Numbers in same column with different letters significantly different ($P < .05$).

grinding to unusually small particle size made the starch susceptible to breakdown by the rumen microorganisms at a rate too rapid for optimum microbial synthesis. Thus, there is a need for further research to determine whether some of the newer processing methods might indeed be equal or superior to fine grinding of sorghum grain under conditions where particle size is allowed to vary.

A comparison of the production of cows fed rations with medium versus finely ground grain merits consideration because the medium ground material would approximate that commonly available at most feed mills. Since, in Trial 1, sorghum grain comprised only 35 percent of the total ration and grinding the grain very finely (see Table 2) gave about a 3 percent increase in milk production, one may surmise that the nutrient value of the grain *per se* was increased by 9 percent. An increase of this magnitude should justify some additional cost for grinding the grain very finely, i.e., using a 3/64 or 4/64 inch screen to produce a product having a geometric mean diameter around 300 microns.

The conclusions in this report about processing of sorghum grain for dairy cows do not necessarily apply to other feed grains. In fact, it was demonstrated many years ago (Wilbur, 1933; Olson, 1942) that medium ground corn and oats were superior to these grains finely ground (pulverized) in terms of milk production of dairy cows.

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Lactose Removal From Cheese Whey Using Saccharomyces Fragilis

Sue Knight, Wanda Smith, and J. B. Mickle

Story in Brief

The purpose was to determine whether yeast could be an effective means of removing lactose from whey. This could materially decrease the organic content, and thus the pollution potential of the whey. A lactose using yeast, *Saccharomyces fragilis* (NRRL-1156), was chosen for this study. The yeast was first cultured in small batches to determine optimum growth conditions, and then in larger batches to simulate commercial conditions.

This study indicated that cottage cheese whey was a good growth medium for the yeast. No additional salt or yeast extract was necessary, but added peptone did appear to accelerate yeast growth. Optimum conditions included a pH of 4.6-5.0, a temperature of 95-104°F, and an air-flow rate of one volume per liter. A series of experiments showed that the yeast completely exhausted the lactose from whey in 7 to 9 hours, with an accompanying decrease in chemical oxygen demand of 60 percent or more.

Introduction

Recent statistics indicate that approximately 22 billion pounds of cheese whey are produced in this country annually. However, only one third of this whey is utilized. The remainder creates a monumental disposal problem since this volume of whey is roughly comparable to the sewage from a city of 210 million people (2). A large amount of oxygen is needed to degrade whey. In fact, one gallon requires the dissolved oxygen in over 4,500 gallons of fresh water for complete degradation (10). A large percentage of this oxygen is used by the lactose present in the whey. This amount of lactose, if dumped into a city's sewer, could completely overload the disposal system (16).

Actually, whey is a very good food—it retains up to 70 percent of the food value of the original milk (4). In addition to the lactose, the whey retains some of the protein and most of the calcium, riboflavin and minerals. The obvious solution would be to feed the whey to animals. However, most non-mammalians cannot utilize lactose, and ingesting any appreciable quantity will cause diarrhea (2). Even among mammals, the adults of the species often lose the ability to digest lactose. Swine, however, usually can tolerate lactose; but because of its high water content (90-93 percent). whey is expensive to haul; and if the swine are very far from the cheese plant, it usually is cheaper to buy feed than to haul whey.

Recent technological advances in whey concentration, i. e., reverse osmosis and ultrafiltration, have supplied a partial answer to the problem. Now whey can be separated into its various components before drying. However, the equipment necessary to do this is quite expensive, and an extremely large volume (100,000 lb/day) is required before the operation can be profitable (21). Spokesmen for the Federal Water Quality Administration have stressed the need for research into whey disposal problems and mentioned that many of the new whey disposal techniques are not economically applicable to the problems of the small cheese plant (2).

The purpose of this study was to determine whether yeast would be an effective method of removing lactose from whey. This also would materially decrease the organic content of the remaining whey. A further purpose was to determine whether this yeast method could be adapted to a small cheese plant operation.

Literature

The research on yeast in general, as well as the lactose utilizing strains, has been reviewed in two recent books (11, 17). Lactose has long been used as a substrate for yeast. In the 1940's Graham, et al., (7) grew yeast in whey to increase its protein content and make it more useful as an animal supplement. They found that aerating the whey-yeast medium produced a higher cell yield. Others have stated that oxygen may be the single most limiting factor in determining yeast yields, and air flow rates ranging from ¼ to 4 volumes of air per minute have been recommended (2,6,14,15,20).

Early research of Porges and co-workers (15) showed that, of the several yeast strains tested, *Saccharomyces fragilis* was the most efficient in converting lactose to new cells. Since that time, the bulk of research done with whey has been done with some strain of this organism. It has been reported that carbon and nitrogen are present in yeast cells at about a 5:1 ratio. However, whey does not contain enough nitrogen to satisfy this ratio (15). Although *Saccharomyces fragilis* can use lactose and lactic acid as carbon sources, it cannot use much of the nitrogen present in whey (19). Apparently it can use soluble nitrogen in the form of peptones or amino acids but will not break down the whey proteins for use as nitrogen sources (8). Therefore, most researchers have added supplemental nitrogen to whey to encourage yeast cell production (7,20).

Most authors stated that *S. fragilis* grows at temperatures ranging from 41°F through 116°F, and recommended an optimum of about 86°F (2,9,13,18). The literature also stated that *S. fragilis* grew over a wide pH range (from 3.0 to 8.0), and researchers have recommended optimum pH values of from 3.5 through 5.7 (3,13,18,20). When S. fragilis was grown in whey, an 85-90 percent reduction in organic matter was achieved in 8 hours providing the whey proteins were removed with the yeast cells (2,3).

Experimental Procedures

S. fragilis (NRRL-1156) was chosen for this study on the basis of literature recommendations. Optimum growth conditions were determined by incubating it first in 100-ml lots of artificial media and later in whey. Final trials used 1,000-ml lots of whey in order to more nearly simulate commercial conditions. Cell growth was determined by turbidity, with lactose and pH values being recorded during the course of all trials (12). On the 1,000-ml trials, the protein content and COD (Chemical Oxygen Demands) of the whey also were determined (1,5).

The amounts of yeast cells produced were determined by microscopic cell counts and by weighing. A constant air flow of at least one volume per minute was maintained through the media by means of submerged gas dispersion tubes, and temperatures were maintained by the use of heated water baths. The equipment was arranged so that up to 12 tubes of media could be incubated simultaneously under similar conditions of temperature and air flow.

The yeast mixture used as a "starter" for these trials was obtained by transferring yeast from a lactose-agar slant into 200-ml of broth containing 4 percent lactose, 2 percent peptone, and 0.1 percent yeast extract and incubating with aeration for 12-14 hours. After this period, the yeast was in the log phase of its growth cycle. A 10 percent inoculation of this "starter" was used for the growth studies.

Results and Discussion

S. fragilis used sucrose and glucose as well as lactose. However, the yeast seemed to grow somewhat better on lactose, with maximum growth when the media contained 4 percent of this sugar (Figure 1 and 2). Lactose is normally present in cheese whey at concentrations of 4-5 percent. Thus, it was concluded that *S. fragilis* would not require a sugar supplement when grown in whey, and the whey would not need to be diluted to achieve optimum yeast growth. Using an artificial medium containing lactose and peptone, it was found that yeast extract furnished a necessary growth ingredient, but the biggest change in turbidity occurred between 0 and 0.01 percent (Figure 3). Therefore, there did not seem to be any appreciable advantage in having more than a trace of this substance in the media.

When using peptone as the nitrogen source in a medium containing 4 percent lactose and 0.1 percent yeast extract, it was found that 2 percent peptone afforded maximum growth (Figure 4). Using a whey medium, attempts were made to replace the peptone with different nitrogen salts

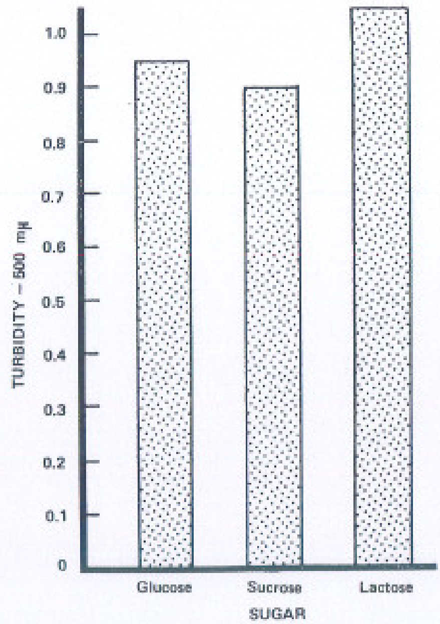

Figure 1. Growth of S. fragilis in artificial media containing 2 percent peptone, 0.1 percent yeast extract, and 2 percent glucose, sucrose, or lactose.

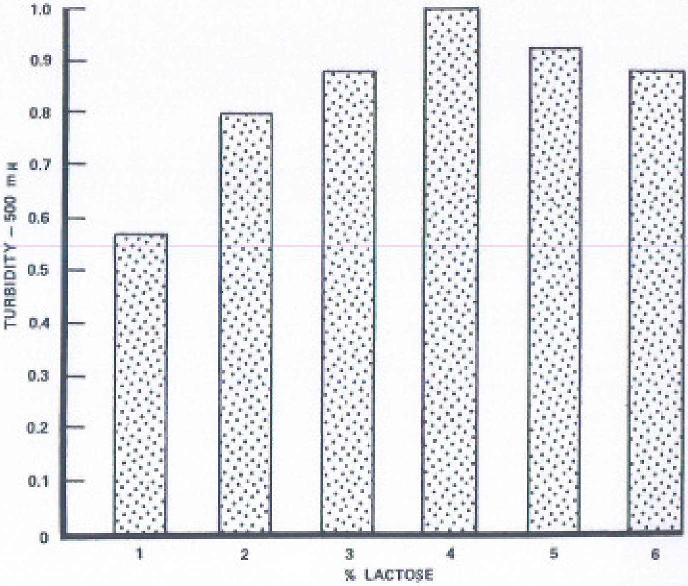

Figure 2. Growth of S. fragilis in artificial media containing 2 percent peptone, 0.1 percent yeast extract, and 1-6 percent lactose.

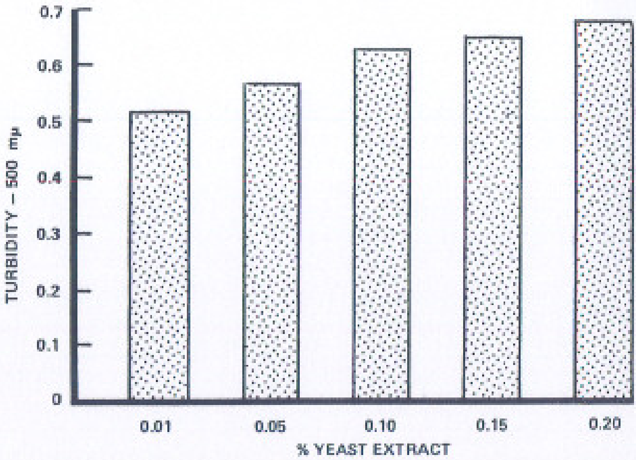

Figure 3. Growth of S. fragilis in artificial media containing 2 percent peptone, 2 percent lactose, and 0.01-0.20 percent yeast extract.

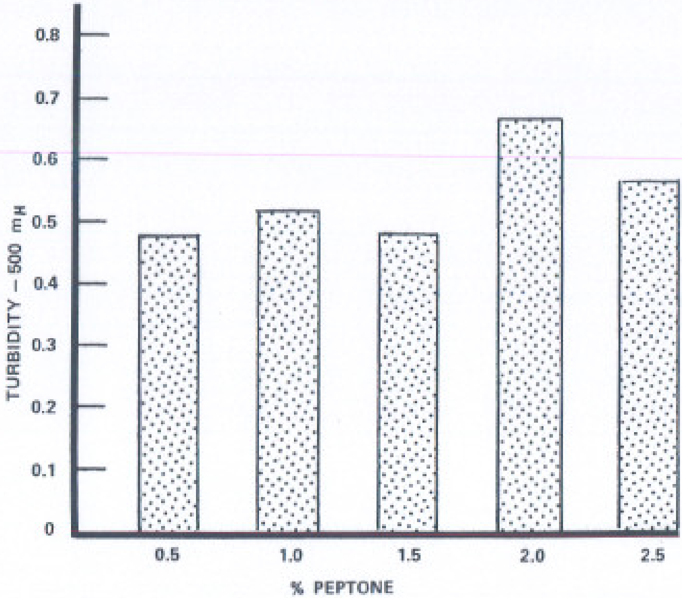

Figure 4. Growth of S. fragilis in artificial media containing 2 percent lactose, 0.1 percent yeast extract, and 0.5-2.5 percent peptone.

including ammonium sulfate, ammonium phosphate, and urea). However, none of these gave growth exceeding that of the peptone control, and many of them actually inhibited the yeast (Figure 5).

Turbidity readings were accumulated from *S. fragilis* grown in similar media under similar conditions while the yeast was in the "log growth phase." Statistical analysis of these data resulted in a standard deviation of 0.02. Thus at the 95 percent level of probability, experimental errors would account for deviations of 0.04 in turbidity readings above or below any given mean. For that reason, unless an experimental treatment gave turbidity readings at least 0.04 higher than the plain whey control, it was not considered to have caused a significant improvement.

S. fragilis grew over a wide range of temperatures and pH values. The yeast showed growth at pH values below 3.0 and above 7.0. However, the optimum growth rates were observed between pH values of 4.0 and 5.0 (Figure 6). The yeast exhibited slow growth at temperatures below 86°F and little growth above 120°F, with the best temperature range being between 96 and 104°F (Figure 7).

An air flow of approximately 1,000 ml/min. (one volume per minute) was maintained throughout the growth period. When the air supply was increased, there was no appreciable increase in cell growth; but when

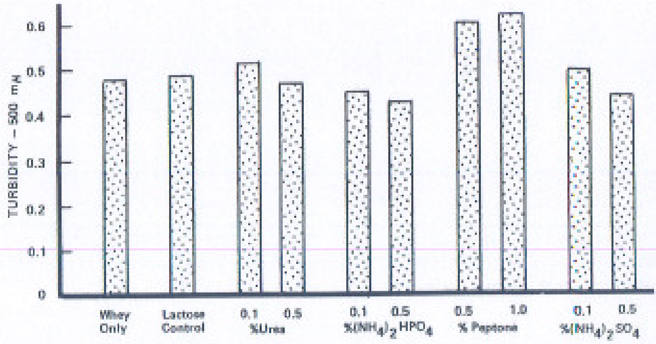

Figure 5. Growth of S. fragilis in whey containing various nitrogen compounds compared to controls of unenriched whey and artificial media containing 4 percent lactose, 2 percent peptone, and 0.1 percent yeast extract.

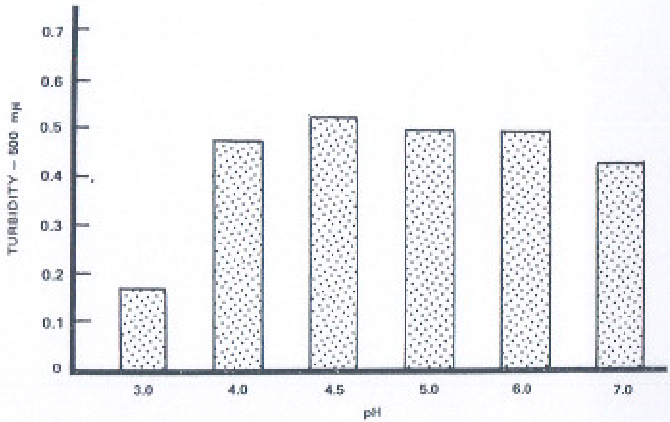

Figure 6. Growth of S. fragilis in whey at various pH values.

the supply was decreased to approximately 350 ml/min., a decrease in growth rate of almost 33 ⅓ percent was noted.

The data from a typical 1,000-ml trial using unenriched whey (Figure 8) show that turbidity readings increased as the lactose and COD decreased. Growth, as evidenced by turbidity readings, leveled off as the lactose in the whey was exhausted. The COD of the whey decreased to near 16,000 ppm (or 1.6 parts per 100 ml) and then also leveled off

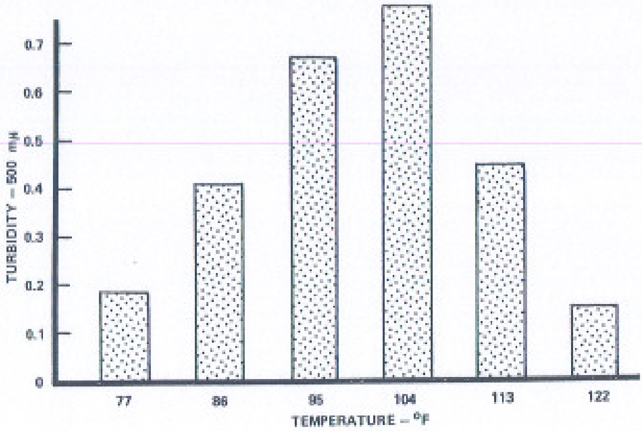

Figure 7. Growth of S. fragilis in whey at various temperatures.

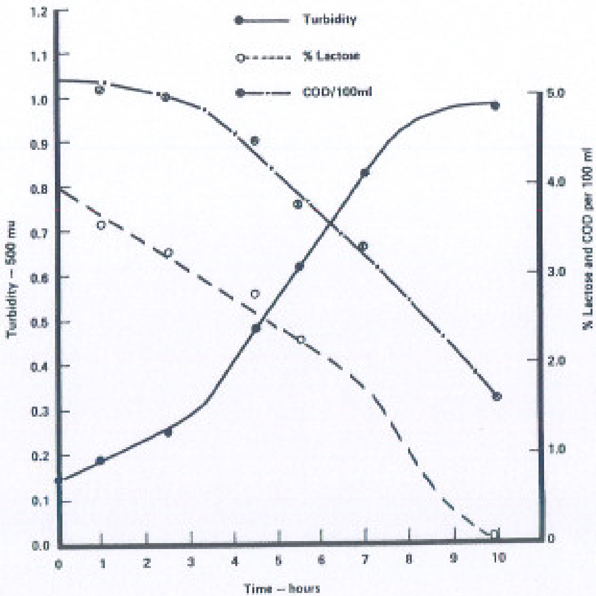

Figure 8. Growth of S. fragilis in whey with corresponding analysis of lactose and COD.

when the lactose was exhausted. This represented a reduction of more than 60 percent in COD. These data were representive of all 12 trials: *S fragilis* consistently exhausted the lactose from whey in 7-9 hours. During this time 0.3 to 0.4 grams of *S. fragilis* cells were produced in each 100 ml of whey. There was about 0.5 percent protein in the original whey, and the yeast used 20-40 percent of it; however, this probably represented the non-protein nitrogen in the whey, since *S. fragilis* cannot use nitrogen in the form of protein (19).

Theoretically, the carbon (from the lactose) in 100 ml of whey should have produced 2.5 grams of yeast cells. Yields of about 2.3 g/100 ml of whey, or 85 percent of this theoretical yield, have been reported (20). In an attempt to explain the apparent discrepancy between the literature and this study, trials were run using inorganic nitrogen, phosphate salts, and yeast extract, as recommended by the literature. These enrichments proved ineffective in the large batches just as they had in the 100-ml trials. In another trial, when 1 percent peptone was added to the whey, a yeast cell weight of 0.5 grams per 100 ml of whey was obtained at the time the sugar was exhausted (Table 1), but 0.7 percent of the protein was not used. This yeast cell weight of 0.5 grams per 100 ml corresponded to a count of 567 X 10^6 yeast cells per ml. Wasserman, et al., (20) using a very large inoculum (500 X 10^6) had final cell counts three to five times this high, which, when related to the data in Table 1, indicated possible increased yeast cell weights of 1.5 to 2.7 grams of cells per 100 ml if sufficient carbon and nitrogen were in the medium to support such growth. Thus, the results indicate that available nitrogen was the limiting factor in these yeast cell yields. Additional usable nitrogen probably would have resulted in greater increases in yeast cell weights, approaching the theoretical limit imposed by the amount of lactose.

Table 1. Growth of S. Fragilis in Whey[1] as Related to Lactose, Protein, and COD Analysis

Time	Turbidity	Cell Count	Lactose %	Protein %		Solids %		COD/ 100 ml
(Hours)	(Absorbance)	(X 10^6)	(Whey)	(Whey)	(Cells)	(Whey)	(Cells)	(Whey)
0	0.70	11	5.2	1.3	0.0	8.1	0.0	7.4
2	0.11	24	5.0	1.3	0.0	7.9	0.0	7.3
4	0.26	81	4.9	1.3	0.0	7.8	0.0	7.1
6	0.59	182	4.0	1.3	0.0	6.5	0.3	6.4
8	0.83	381	1.5	1.1	0.2	4.5	0.3	4.1
9	1.00	567	0.0	0.7	0.6	1.8	0.5	1.6

[1] Whey contained 1% added peptone.

However, the purpose of this work was to reduce the COD value of the whey as quickly as possible—not necessarily to produce yeast cells. Relatively small inoculums of *S. fragilis* consistently reduced the COD of the unenriched whey from over 50,000 to less than 20,000 ppm in about eight hours. Added nitrogen (to produce more cells) made the process more expensive. In addition, the extra nitrogen did not appreciably shorten the time needed to exhaust the lactose from the whey; and most of this extra nitrogen remained in the whey increasing the disposal problem.

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Heat Tapes—An Aid in Heat Detection

Milton Wells and Glenden Adams

Story in Brief

The use of artificial insemination continues to increase in both dairy and beef herds. It is estimated that approximately 30 percent of our dairy cattle and 2 percent of our beef cattle in Oklahoma were artfficially inseminated in 1971. It is expected that we will see increasing use of this beneficial technique in the next few years.

An ever-present problem facing those wishing to use artificial insemination is having a satisfactory heat detection program. One of the major factors involved is lack of time, especially in busy seasons, to spend with the herd looking for cows in heat. Another factor is that some cows have either low-intensity heats or short heats which makes it harder to observe when these animals are in heat. Heat detector tapes are available which are supposed to aid in detecting a higher percentage of cows in heat than can be detected visually. The intent of this research was to compare the efficiency of heat detection by visual observation only with that possible with visual observation plus heat tapes.

Heat tapes aided heat detection significantly. Visual observation detected 87 percent of the possible heats while visual observation plus heat tapes detected 96 percent of the possible heats.

Introduction

As our dairy farms become larger, good labor harder to secure and our management requirements more complex, many dairy men are having less time to devote to the job of getting a high percentage of the herd safely with calf in the desired period of time. There is little doubt that artificial insemination allows many dairymen access to bulls they could not afford to own. However, if the net result is longer calving intervals and fewer cows delivering calves, then the advantages of artificial insemination are of little real value. It has been recommended that heat checks should be made twice daily. However, research results indicate that with twice daily observation, about 20 percent of the heats will be missed. Increased frequency of observation (3 to 4 times daily) typically reduces

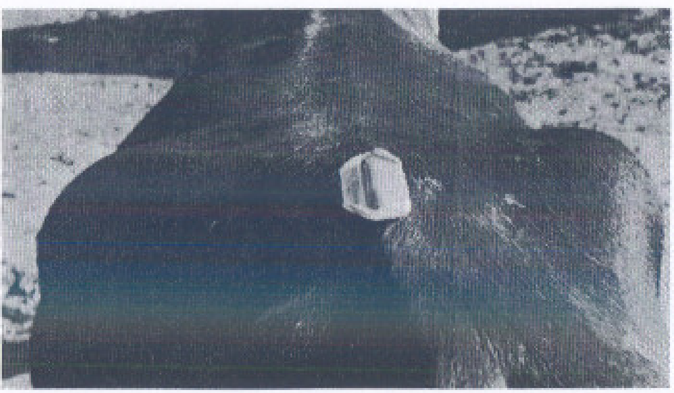

Figure 1. Heat tape properly placed on the cow.

the number of missed heats to less than 10 percent. However, competition for the dairyman's time does not allow this to be a widely used solution. In fact, regular, twice daily observation is difficult for some to achieve.

In Michigan, the percentage of dairy cattle bred by artifical insemination is steadily declining as dairymen turn back to using bulls. The main reason for this is that they do not have the time to devote to an adequate heat detection program.

One of the aids currently advertised as helping achieve a high percentage of detected heats is the KAMAR heat tapes. This red-ink-filled capsule device is glued just in front of the tail-head of the cow. When the cow stands to be ridden by another animal, the capsule breaks and stains the patch a bright red. This research explored the problems in using these tapes and compared the efficiency of heat detection by visual observation only with that attained by visual detection aided by heat tapes.

Materials and Methods

Ninety-four normal cows and heifers in the Oklahoma State University dairy herd were paired by breed and stage of lactation. At 45 to 50 days after calving, a heat tape was fixed to one member of each pair of animals. All animals were maintained in their respective milking groups. Checks for visual heat signs were conducted 2 to 3 times daily on all animals. In addition, those cows with tapes were checked to see if the cow had accepted a ride in between the visual heat checks. Cows observed in heat (by either or both methods) were bred in the evening if observed in the morning and in the following morning if observed in the evening.

The efficiency of heat detection was determined by computing the percentage of the possible heats that were actually detected in a period of time. For example, if 10 cows were started on the study on a given date, all 10 cows (if they are normal) should cycle within 24 days.

Results and Discussion

The results of this study are summarized in Table 1. In the animals that were checked by visual observation only, 45 heats were possible. Of this number 39 heats were detected for an 87 percent detection rate. With the animals that were checked by heat tapes in addition to visual observations, 49 heats were possible. Of this number, 47 heats were detected for a 96 percent detection rate.

Several observations can be made from this study. First, we were able to achieve a higher degree of detection visually than several studies have reported. However, we apparently were still missing some heats since we achieved an even higher rate of detection with visual observations aided

Table 1. Efficiency of Heat Detection

Group	Possible heats	Heats detected	Detection rate
	(No.)	(No.)	(%)
Visual only	45	39	87
Visual plus heat tapes	49	47	96

by tapes. Some heats were detected at night by tapes only as were some heats during the day periods. This points out the basic advantage of heat tapes—they tell what happened when man was not there to observe. It would appear that the heat tapes can be a distinct aid to heat detection, not only in those busy periods, but in all efforts to get the cows bred back as efficiently as possible.

This study also points out that very few of our normal cows have true silent heats, we more than likely are failing to observe our cows frequently enough to catch normal heats.

Concern has been voiced over how durable the tapes are. Many of the tapes in this study were applied and worn in rainy weather and minimum difficulty was encountered with lost tapes or slipping tapes.

Very little difficulty was encountered with "false positives", i.e., rupture of the tape when the cow was not actually in heat. This can be eliminated almost entirely by placing the tape on the cow properly (see Figure 1). It should be placed so that it takes a standing ride with full chest and brisket pressure to reach and break the tape. Some difficulty was encountered with unbroken tapes on some cows with high tail heads or roughness in the area from rump to pins. More care in tape placement is required on such cows.

Another advantage in using a visual aid is that it makes you keep up with the status of cows closer. We can overlook cows and fail to start breeding them at the proper time with long calving intervals being the end result. The heat tape on a cow signals all concerned that she is eligible to be bred.

The results of this study are in good agreement with other similar studies and indicate that heat tapes can be a distinct aid in detecting heat.

The Effect of Freezing Rate On Sperm Cell Characteristics

Milton Wells and Mark Hodson

Story in Brief

Bull sperm cells can be stored successfully for several years in liquid nitrogen. Although the freezing process does kill a relatively large number of live cells, this problem is compensated for by starting with an increased number of cells prior to freezing. Research through the past years has defined the optimum rate of freezing bull cells with the major criterion for gauging success being the survival pattern post-freeze. Apparently, the typically used freezing rates also have given reasonable acrosome condition post-freeze.

On some bulls and in boars and rams, it is most difficult to successfully freeze their cells. Sperm cells can apparently survive the freezing process but fertility is not acceptable. It is known that the freezing process does affect the acrosome and it was of interest to explore the effect of freezing rate on the acrosome. Bull sperm cells were frozen at five different rates, ranging from very slow to very fast. Ampules were thawed and examined for percent live cells and aged acrosomes.

Under the conditions used in these trials the moderate rate of freeze (5.5° F/minute) gave the best survival post-freeze with acceptable condition of the acrosome.

Introduction

The backbone of our modern-day artificial insemination industry is the capability to freeze and store sperm cells for an extended period of time. Bull cells and stallion cells can now be frozen and stored successfully as judged by fertility and livability studies. However, on some bulls' cells and cells from boars and rams, good post-freeze livability can be achieved, however, fertility is not acceptable.

Recent studies on boar sperm suggest that when acrosomal integrity is preserved, satisfactory fertility is achieved even when post-freeze motility is low. The above facts suggest that criteria other than post-freeze motility are involved in maintenance of fertility. In view of this, several facets of sperm cell preservation procedures are being re-examined to determine how the acrosome is affected. This study was undertaken to evaluate the effect of freezing on morphological integrity of the acrosome and sperm cell livability.

Materials and Methods

Four dairy bulls, 4 years old, housed and managed similarly, were used in this study. Semen was collected from these bulls once weekly for 5 consecutive weeks. Initial ejaculate characteristics measured were as follows:

a) Volume
b) Sperm cell concentration
c) Percent live sperm cells
d) Percent aged acrosome

All ejaculates were diluted to obtain approximately 30 million live sperm per ampule prior to freezing. The diluter used was a standard egg yolk-sodium citrate-glycerol mixture. Freezing was accomplished 5-6 hours after dilution by placing the canes of semen in a wire rack and lowering them into a thick-walled styrofoam box containing 3 inches of liquid nitrogen.

In this split-ejaculate study, ampules from each bull were frozen at the following rates:

a) slow, .9° F/min from 41° F to —22° F, then 5.5° F/min to —55° F;
b) moderate, 5.5° F/min from 41° F to —55° F;
c) intermediate, 7.5° F/min from 41° F to —22° F, then 30° F/min to —55° F;
d) rapid, 17° F/min from 41° to —55° F;
e) accelerated, 35° F/min from 41° F to —55° F.

The ampules were all frozen from —55° to —125° F at 35° F/min and then transferred to a liquid nitrogen tank. The ampules were thawed 24 hours later and were evaluated for acrosomal state and percent live cells.

Results and Discussion

Effects of freezing rate on percent live cells.

All rates of freeze drastically reduced the percentage of live cells from the initial evaluations (Figure 1). The slow rate was apparently the most harmful as there was only an average of 17 percent live cells post-freeze. The moderate rate gave the highest percent live, 29 percent, with the faster freezing rates resulting in fewer live cells per ampule. These results are in good agreement with several studies that indicate that sperm cells should be frozen at a rate of 5-8° F per minute from +41° F to —4° F.

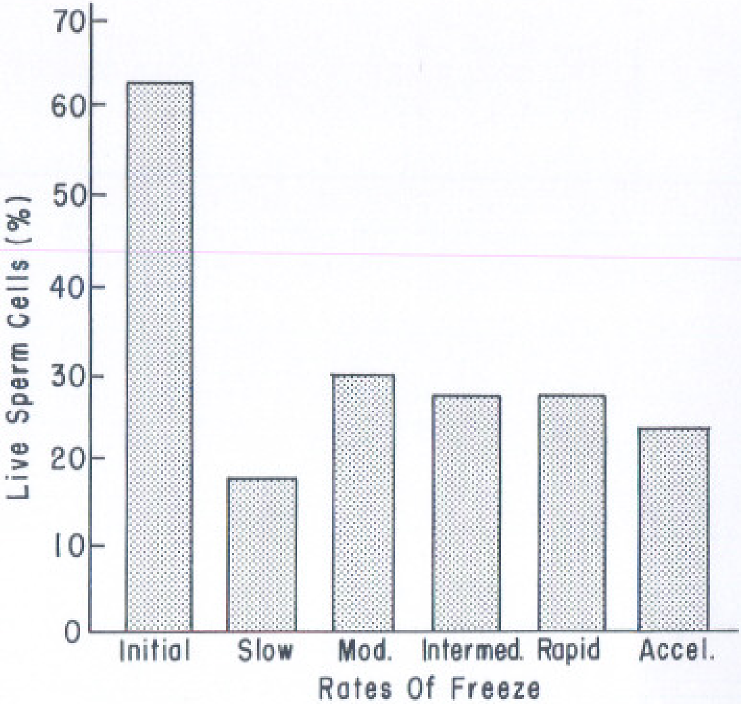

Figure 1. The effect of rate of freeze on percent live sperm cells. (20 observations per mean).

The data also indicated that bull differences and semen quality differences unique to a given collection day may influence how a sample of cells will freeze. This agrees well with our experience that some bulls' cells are occasionally difficult to freeze.

Effects of freezing rates on acrosome status.

Figure 2 presents the average percentage of aged acrosomes for all rates of freeze. All rates of freeze essentially doubled the degree of aging noted in the average initial ejaculate (21 percent). The slow, intermediate and accelerated rates appear to cause aging to a greater extent than the moderate and rapid rates. However, more ejaculates from a greater number of bulls are needed to verify this as fact. There were significant differences among bulls and dates of semen collection in response to the rates of freeze. This reinforces the facts as we already know them, namely, we can expect bulls to differ in response to treatment of

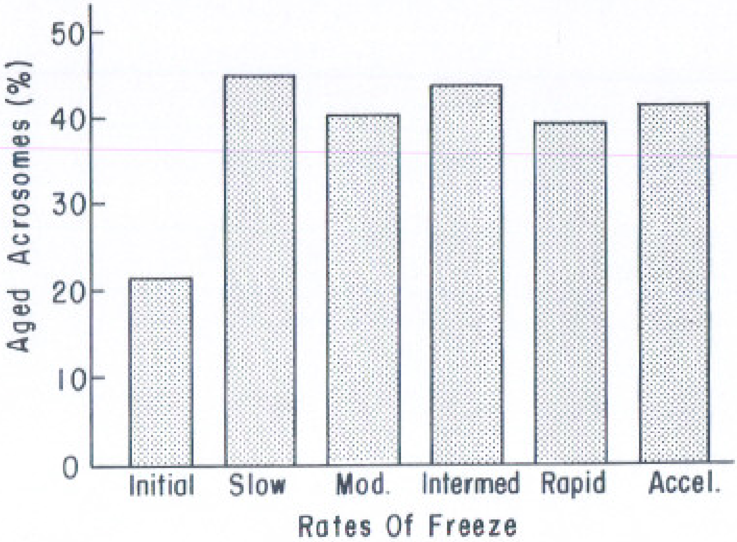

Figure 2. The effect of rate of freeze on percent aged acrosomes. (20 observations per mean).

their cells and it is not unusual to have large differences among the ejaculates of a bull in response to rates of freezing.

There were highly significant interactions among bulls, rates and dates of collection. Simply stated, this means that (1) semen from different bulls responded differently to the various rates of freeze, (2) the semen from different bulls responded differently on different dates, and (3) different rates of freeze had different effects on different dates.

This complexity of factors tells us that it is most difficult to make clear-cut projections as to how freezing will affect the acrosome of bull sperm cells. It is imperative that further research be conducted to clarify each factor's relative contribution to the maintenance of acrosomal integrity through the freezing process.

SUMMARY REPORTS ON OTHER PROJECTS

Cow-Calf

Problems Associated with Induced Superovulation and Superfetation in Beef Cows

E. J. Turman, Monte R. Johnson and D. F. Stephens

Previous research has demonstrated that the incidence of multiple births in beef cattle can be greatly increased by injections of the gonadotropic hormone preparation, pregnant mare serum (PMS). The treatments imposed on cows calving in 1971 were designed to study the effectiveness of PMS injections that are timed from a synchronized estrus rather than from a naturally occurring estrus. If feasible, this would greatly reduce the labor requirements by eliminating the need for daily heat checks and PMS injections on an individual cow basis.

Estrus was synchronized in a total of 51 cows by feeding an oral progestogen (CAP, Eli Lilly Co.) for 18 days. Most cows were in estrus on day-2, 3 or 4 following the last feeding of CAP. Day-3 was designated as the average day of estrus and PMS injections were timed from this date, being administered to all cows on the 5th and 17th day following the average day of estrus. A group of 15 control cows were not synchronized and also received their PMS injections on day-5 and 17 following the naturally occurring estrus in each individual cow.

Fewer synchronized cows conceived at the first post-PMS estrus when superovulation would be expected to occur as a result of PMS injections. Thus, multiple births would be expected only to conceptions at this estrus, and in our research to date this has held true with no exceptions. The numbers of cows conceiving at the first post-PMS estrus were: controls, 9 or 60 percent, and synchronized, 10 or 19.6 percent. However, the multiple bitrh response of the synchronized group was good, with 8 of the 10 cows producing multiple births, compared to 4 of the 9 control cows. The total multiple births obtained in 1971 from both groups of cows were 7 sets of twins, 4 sets of triplets and 1 set of quadruplets.

The results obtained in the control group of cows is comparable to that observed in previous years in cows treated similarly. The multiple birth response of synchronized cows is encouraging. It's use could do much to make PMS treatments more practical. However, additional research is needed to attempt to improve conception rates.

Publications

The following articles have been published from this project during the past year.

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Selection for Increased Weaning Weight and Yearling Weight in Beef Cattle

R. R. Frahm

The beef cattle selection study being conducted at the Fort Reno Livestock Research Station involves both purebred Angus and Hereford cattle. The objective of this study is to determine the direct and correlated genetic responses to selection based on weaning weight and yearling weight, respectively. The experimental design for this study is presented in Okla. Agr. Exp. Sta. Misc Pub. 85:150. Of particular interest in this study will be the magnitude of the genetic correlation between weaning weight and yearling weight since it will largely determine the extent to which weaning weight performance data can be utilized as an indicator of genetic potential for rapid growth over the entire growth curve.

Several more years of data will be required before critical evaluation of selection responses can be made in this study. Comparisons can, however, be made that will provide some indication of the genetic changes that are perhaps occurring in the selection lines. Since the study was initiated in 1964, the level of performance for both weaning weight and yearling weight in lines being selected on the basis of weaning weight has been very similar to that in lines being selected on the basis of yearling weight. While this information does not indicate the amount of change in performance due to selection, it does suggest that the genetic changes resulting from selection based on weaning weight and yearling weight have been similiar thus far in the study.

Comparing performances of approximately the top 20 percent of the bulls produced in the selection lines (one Hereford and one Angus line selected on weaning weight and one Hereford and one Angus line selected on yearling weight) provides some indication of the genetic relationship between weaning weight and yearling weight. During the past 4 years the top bulls in the two weaning weight lines had an average weaning weight ratio of 1.12 whereas their average yearling weight ratio was 1.08. Of these 32 top bulls based on weaning weight only 6 were below average on yearling weight. The top 32 bulls in the two yearling weight lines had an average yearling weight ratio of 1.12 whereas their average weaning ratio was 1.10. Of these top 32 bulls based on yearling weight only two were below average based on weaning weight.

These comparisons indicate that the top bulls in the four selection lines tended to be above average for both weaning weight and yearling weight, and irregardless of which trait selections were based on the use of these selected bulls would be expected to result in genetic improvement for both traits.

Publications

Cardellino, Ricardo and R. R. Frahm. 1971. Evaluation of two types of age of dam correction factors for weaning weight in beef cattle. J. Anim. Sci. 32:1078.

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Comparison of Productivity Among Certain F_1 Crossbred Cow Groups

R. R. Frahm

Research has shown that production in terms of pounds of calf weaned per cow exposed for breeding can be increased at least 15 percent through utilization of a systematic crossbreeding program. Crossbreeding increases production by providing an opportunity to capitalize on combining the desirable characteristics of two or more breeds and by taking advantage of heterosis. The particular traits that have shown the most gain from heterosis have been those affecting reproductive efficiency and maternal performance of the cow and early growth rate of the calf. Thus, the crossbred cow is a major component of increased production through crossbreeding.

The purpose of this newly initiated study is to compare lifetime productivity under range conditions of eight F_1 crossbred cow groups (Hereford-Angus, Angus-Hereford, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) when mated to a terminal cross sire of a third breed. The eight F_1 crossbred cow groups will consist of 45 cows each made from appropriate matings to comparable sets of Angus and Hereford cows made over a three year period. A foundation herd of 200 Angus and 200 Hereford cows that are typical of good commercial Angus and Hereford cattle in Oklahoma have been assembled at the Lake Carl Blackwell range to produce the respective eight F_1 crossbred cow groups starting with the 1972 breeding season. The lifetime productivity of each crossbred cow group (approximately 10 calf crops) will be compared when mated to a common set of bulls.

Shorthorn and Red Poll bulls will be used to sire the calves produced by the crossbred cows as 2-year-olds. Charolais bulls will be used for the second and subsequent calves until the three different age groups of crossbred cows all reach maturity at which time one other breed can be introduced in any one year for comparison with Charolais as a terminal cross sire breed. Decisions relative to which breed or breeds to involve in this comparison will be delayed until that point in the study is reached pending evaluation of data available on potential terminal sire breeds at that time.

Data will be collected on the reproductive and maternal performance of the cows, growth rate of all calves to weaning and feedlot performance and carcass evaluation of the steer calves.

Results from this study will provide basic information on how systematic crossbreeding programs utilizing available genetic resources (breeds) can be developed that will maximize production under Oklahoma range conditions.

Relationship Between Propertites of Southern Forages and Animal Response

J. E. McCroskey

Research studies have shown that forages grown in the southern part of the United States have different chemical characteristics, and are frequently lower in quality than forages grown in the central and northern states.

In an attempt to characterize as completely as possible the chemical and physical characteristics of these forages, Oklahoma has joined with 12 other southern states in a regional forage study. The primary objective of this cooperative study is to obtain detailed chemical properties and animal responses from seven species of forages which are characteristic of those grown in the southern states. Each forage will be harvested at three stages of maturity. Departments of Animal Science, Agronomy and Biochemistry are cooperating in this effort.

Oklahoma's contribution is to produce four species of forages (alfalfa, bermudagrass, fescue and a sorghum-sudan hybrid), each at three stages of maturity. Animal data to be collected on these forages include rate of gain, feed efficiency, voluntary feed intake and a determination of digestible energy, metabolizable energy, and net energy. In addition, detailed laboratory analyses will be determined to characterize the forages with regard to all chemical properties known to be important in measuring quality.

During the summer of 1971, a sorghum-sudan hybrid (haygrazer) was harvested. Laboratory analyses and animal response data are in the process of being collected. One forage will be produced each year until all four forages have been studied.

Upon completion of the regional project, the seven forages will be rather completely characterized with regard to animal response and chemical composition standpoints. These data should be quite useful in determining the feeding value of these and other similar southern forages.

Development of Regression Equations for Predicting Performance of Cows and Calves Grazing Bermudagrass Pastures

J. E. McCroskey

Prediction of performance of grazing animals is rather difficult and depends primarily upon the quality of forage available and the amount the animal consumes. There are no accurate, direct methods for measuring or predicting the amount of bermudagrass which grazing cattle consume. Therefore, a study was initiated at the Ft. Reno Experiment Station to determine intake of grazed bermudagrass by cows and calves, and to establish mathematical equations for predicting intake.

Midland Bermudagrass fertilized at three levels of nitrogen (60, 180, and 300 lb. N./A.) will be used in an attempt to obtain a wide range in quality of bermudagrass pasture. Sixty Angus X Hereford crossbred cows, calving for the first time in the spring of 1972, will be assigned to the three treatments at calving time and will be used to measure forage intake at five times during the year over a five-year period. Intake of pasture by their calves will be determined three times during the nursing period. Esophageal fistulated cows and calves will be used to collect forage samples for laboratory analysis. In addition to forage intake determination, data will be collected on forage available per acre, cow weight changes, and calf weaning weights.

At the end of the study data obtained on forage chemical characteristics, yield of forage, and intake of grass by cows and calves will be used to establish regression equations for predicting intake of bermudagrass. For practical use, we should be able to calculate forage intake and animal performance if we have a measure of the amount of forage available, and its chemical characteristics.

Results of the first year's study will be reported in the 1973 Animal Sciences and Industry Research Report.

Studies on Nutritive Value of Wheat Pasture

R. R. Johnson, M. McGeehon and I. Williams

Although small grain pasture has been a valuable source of winter grazing for cows, stockers and sheep for several years, studies on the nutritive value of winter small grain forage are very limited. The impossibility of harvesting sufficient small grain forage for digestion studies and growth trials in stalls and pens makes such an investigation even more difficult. Consequently, a study was initiated this past year to utilize newer laboratory methodology to investigate the nutritive characteristics of small grain pasture.

Wheat pasture samples are being harvested from experiment station plots at various times during the winter. The samples are frozen in the field at the time of harvest by placing in dry ice and stored at —20° C. Special techniques are used to grind this material without thawing or dehydrating it so that the samples analyzed are truly representative of the type of material consumed by animals.

Samples are being analyzed for:

- Soluble carbohydrate
- Cell wall constituents
- Acid detergent fiber
- Total crude protein
- Non protein nitrogen
- Rate of ammonia liberation when incubated with rumen microorganism
- Dry matter disappearance and gas production when incubated with rumen microorganisms

Preliminary data accumulated to date shows that the total crude protein may be as high as 30 percent of the dry matter and decreases to 15-20 percent toward the latter part of the winter season. Approximately ⅙ of this crude protein is in the form of non-protein nitrogen in early harvests. Soluble carbohydrate is low (8 percent) in late October but increases (15-20 percent) in late November. Samples harvested after that date have not yet been analyzed.

Mouse Selection Studies As An Aid To Animal Breeding Research

R. R. Frahm, I. T. Omtvedt and C. R. McLellan, Jr.

Studies are being conducted with mice to obtain a basic understanding of the genetic interrelationship that exist among growth rate at different stages of the growth curve and with other performance and productivity traits. Knowledge of these genetic relationships will aid in the development of more effective breeding programs to improve the performance level of the livestock species.

A selection study with mice is currently underway to specifically measure direct and correlated response to selection for preweaning and postweaning rate of gain for the purpose of determining the genetic correlation between growth rate at these two intervals in the life cycle. This study consists of 6 selection lines of 20 litters each (3 lines being selected on an intralitter basis for increased 3 weeks weight and 3 lines selected for increased average daily gain from 3 to 6 weeks of age) and a random mating control line of 40 litters that is used to measure genetic changes that occur in the selection lines.

After 6 generations of selection the average 3 week weight of the 3 lines selected for preweaning growth was 10.7 grams which was 1.3 grams (13.8 percent) heavier than the control line, and average daily gain from 3 to 6 weeks of age in the 3 lines selected on the basis of postweaning growth rate was 0.85 gram/day which was 0.15 gram/day (21.4 percent) higher than the control lines. Selection has effectively altered the genetic capabilities of the mice for rapid growth both preweaning and postweaning, respectively. Average daily gain from 3 to 6 weeks of age was essentially the same in the preweaning selection lines as the control line. However, the 3 week weight in the postweaning gain lines was 0.3 gram (3.2 percent) heavier than the control line indicating that selection for increased postweaning growth rate has also resulted in some genetic improvement for preweaning growth rate.

In order to determine if the total weight of a particular muscle system can be altered by selection, another study was initiated in which one line was selected on the basis of the heaviest weight of the hindleg muscle system and a second line was selected on the basis of the lightest hindleg muscle in the mature male mouse (12 weeks of age). After six generations of selection the total hindleg muscle weight was 2.82, 2.66

and 2.11 grams in the heavy-muscle, control and light-muscle lines respectively. Selection for heavy muscle weight resulted in a 6 percent increase over the control line, whereas selection for light muscle weight resulted in a 20.7 percent decrease from the control line which indicates that selection for reduced muscle weight was considerably more effective than selection to increase muscle weight.

The correlated response in live weight at 12 weeks (age at which muscle weight was determined) exhibited a very similar pattern in the selection lines as the change in muscle weight. Consequently, the ratio of muscle weight to 12-week live weight was simular in the heavy muscle and control lines. However, the ratio of muscle weight to 12-week live weight declined in the light muscle line and was significantly lower in generations 4, 5 and 6. Body composition analysis conducted in generation 5 showed that the percent protein, either extract, moisture and ash was essentially the same in the heavy muscle, light muscle and control lines. This indicates that selection based on hindleg muscle system weight has not resulted in an alteration in the body composition of the mice.

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Evaluation of the K^{40} Technique for the Determination of Muscle Potassium and Fat-Free Lean in Ground Meat

T. R. Carr, L. E. Walters, R. D. Morrison and R. F. Queener

Recent research concerning the element potassium and its relation to other body and carcass constituents has led to the development of whole-body K^{40} counting methods for determining differences in the lean content of live animals.

There are two properties of potassium that make its quantitative measurement in animals and their tissues both useful and practical. First, the measurement of potassium is useful in live animal composition studies because potassium appears to be relatively independent of body fat and to make up a relatively constant proportion of the fat-free body when considered within species and age groups. Further, because a large proportion of the intracellular fluid occurs in the muscle and because of the high concentration of potassium in the intracellular fluid, potassium shows promise as an index of the amount of muscle present in an animal or a meat sample. Secondly, the measurement of potassium is possible because a small but constant proportion of potassium is radioactive. By measuring the amount of radioactivity arising, specifically from the potassium in an animal, instruments such as the O. S. U. whole-body counter have made it possible to measure the amount of potassium in meat animals and from these data to estimate the amount of muscle in the living animal with considerable accuracy.

The search for a rapid, accurate method for determining muscle potassium and fat-free lean in ground meat samples has prompted the investigation of two new detector configurations in the O. S. U. K^{40} whole-body counter. The development of such a technique could result in considerable savings in chemical analyses, as well as to initiate the

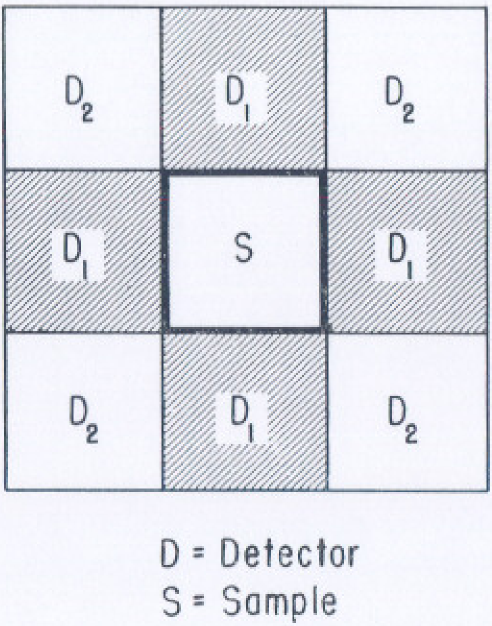

Figure 1. Schematic of Tunnel K^{40} counting configuration.

development of technology in this area applicable to improved quality control methods in the meat industry.

Experiment I. These studies involve the use of eight detectors (6½" X 6½" X 60") arranged in such a way as to create a tunnel in which samples can be placed for counting, Figure 1.

In this experiment only the D_1 detectors were used to monitor potassium radiation from the ground meat samples. Research is currently in progress in which all eight detectors are activated for monitoring and K^{40} counting.

Preliminary results using 40 pound sugar phantoms containing known concentrations of potassium (KCl) indicate that net K^{40} count is closely related to the concentration of KCl in the phantom as is shown in the plot of Logarithm-Net K^{40} counts versus potassium concentration, Figure 2.

Experiment II. A. In these studies, the phantoms were replaced by lean ground beef samples containing different levels of added fat and different concentrations of lean. A plot of the K^{40} counts (obtained when using the tunnel configuration described in Exp. 1) and ground beef composition is presented in Figure 3. These results also suggest a rather strong relationship between net K^{40} counts and lean concentration in the sample. Further work is necessary to more completely establish the counting efficiency of the system and to develop the necessary prediction equations for application to an analytical procedure.

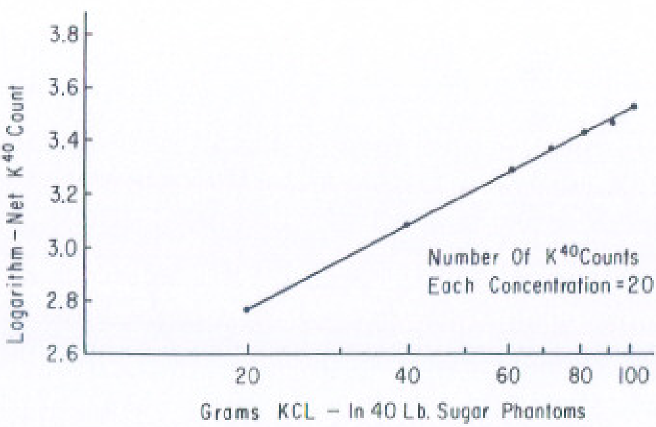

Figure 2. Logarithm-Net K^{40} count as related to potassium concentration.

Table 1. Composition of ground beef samples: Experiment II. A.

	Lbs. Lean Ground Beef	Lbs. Added Fat
Sample 1	30.0	10.0
Sample 2	32.5	7.5
Sample 3	35.0	5.0
Sample 4	37.5	2.5
Sample 5	40.0	0.0

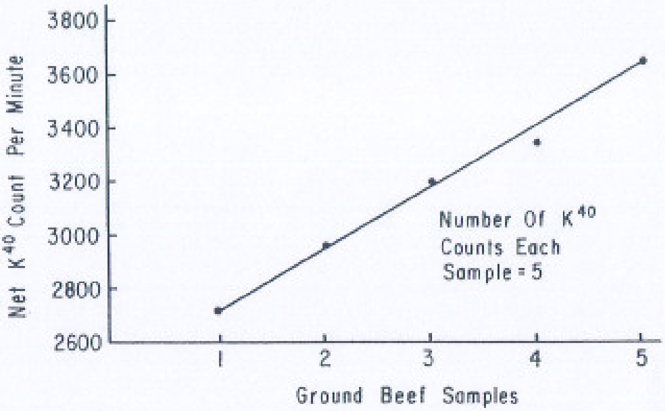

Figure 3. Net K^{40} count as related to different lean concentrations in in ground beef.

Experiment II. B. Another series of K^{40} evaluations were made using different levels of fat added to lean ground beef. The plot of net K^{40} counts and ground beef composition for this experiment is presented in Figure 4.

Table 2. Composition of ground beef sample: Experiment II. B.

	Lbs. Lean Ground Beef	Lbs. Added Fat
Sample 1	32.0	8.0
Sample 2	36.0	4.0
Sample 3	38.0	2.0
Sample 4	39.0	1.0
Sample 5	40.0	0.0

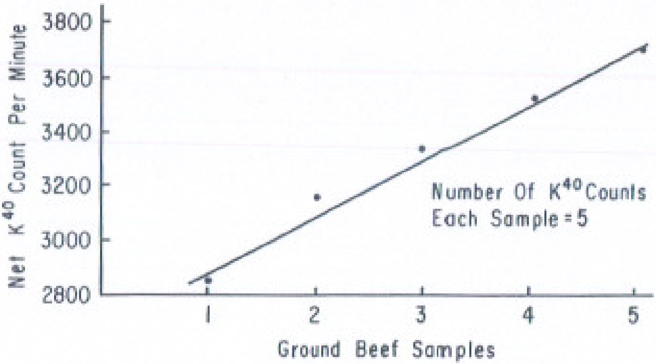

Figure 4. Net K^{40} count as related to different lean concentrations in ground beef.

Both Figures 3 and 4 suggest a linear relationship between net K^{40} count and known amounts of fat and lean in the ground meat samples. After further research and statistical analyses of the data, prediction equations may be developed which will perhaps enable one to estimate the fat-free lean percentages in ground meat samples by using the K^{40} counter.

On the basis of these preliminary results, a "cube counter" has been constructed which will accomodate a seven pound ground meat sample and allow for K^{40} monitoring through detector surfaces placed on all sides of the sample. This is in contrast to radiation monitoring from 4 sides of samples in the "tunnel" configuration described in Experiments 1 and 2 above. Thus, the "cube counter" more completely surrounds the sample with radiation detectors than is possible in the "tunnel" configuration. These studies are now in progress. The data will be analyzed statistically and a more complete report will be made at a later date.

A Characterization Of Myodegeneration Syndrome In Porcine Muscle

S. N. Falk, R. L. Henrickson, C. V. Maxwell and R. J. Panciera

Forty market weight Yorkshire hogs were used in this study. The animals were exercised on a treadmill and then slaughered at which time the intramuscular temperature and pH of the muscle were determined. Histochemical evaluation involving the DPNH-TR technique was used to determine the oxidative potential of the muscle. Carcass evaluation included color, firmness, marbling of the loin, lean cut yield, carcass length, loin eye area and weight. Chemical evaluation of the Longissimus dorsi included moisture and fat analysis. Fiber diameter and degree rigor were also measured and compared with shear data obtained from the Warner-Bratzler shear instrument.

No relationship was found between live weight and susceptibility to Myodegeneration Syndrome between groups, however, hogs with low initial muscle pH exhibited pre-slaughter characteristics of previously reported syndromes and had higher post-mortem intramuscular temperatures than those with intermediate and high initial pH. Carcass evaluation revealed no differences in chilled side weights, however, the "susceptible animals" had a greater percentage of live and carcass lean cuts and were shorter and more compact than the "normal" animals.

Differences in quality were readily observable and agreed well with previous investigations of pale, soft, exudative pork (PSE). "Abnormal" and "intermediate" carcasses had larger Longissimus dorsi areas and weights. Also animals with low and intermediate initial pH had lower percentages of fat and higher percentages of moisture than those with high initial pH. Histological analysis revealed no differences in fiber diameter among groups, however, the degree of rigor (percent kinkiness) was higher when the initial muscle pH was low or intermediate and agreed well with shear data.

The histochemical analysis demonstrated that "abnormal" and "intermediate" animals had fewer red and more intermediate muscle fibers than did "normal" animals, while white fiber content was relatively consistent between groups. These data agreed well with previous investigations.

Physical Properties of the Skeletal Muscle Fiber

R. L. Henrickson and J. C. Marsden

The shear force of muscle tissue has been extensively investigated, but rarely at the fiber level. Most studies have been concerned with cooked pieces of meat one-inch in diameter. This project involves an investigation of shear force and related physical properties of the muscle fiber. Continued research will determine the influence of these properties on tenderness.

The sartorius muscle from 18 sides of beef were excised hot at 2, 5, and 8 hours postmortem. Those from the opposite side were excised after the carcass had chilled at 32°F. for 48 hours. One hundred fibers from each muscle were appraised for shear force, fiber diameter, and degree rigor-mortis. Thus, the 1800 fibers from the hot excised muscles were compared to the 1800 fibers excised after the muscle had chilled.

Fiber diameter and degree rigor of fibers from the cold excised muscle showed little variation. For the muscles excised hot, the fiber diameter and degree rigor decreased as the holding period increased.

In terms of average shear force (g/u^2) for individual muscle fibers, the cold excised muscles showed a difference ranging from 1.74×10^{-3} to 1.83×10^{-3} g/u^2. The fiber from the hot excised muscles ranged from 1.71×10^{-3} to 2.90×10^{-3} g/u^2. In general, the shear force decreased as the holding time increased.

For fiber diameter, shear force, and degree rigor the holding time (2, 5, and 8 hours) treatment (hot or cold), and treatment holding time interaction were all significant at the $(p<.05)$. Correlations and repeatability studies are in progress.

Fiber tensil strength investigations utilizing the Instron Universal Testing Machine have been accomplished using 25 fibers from each of 6 muscles.

Influence Of "Hot" Boning On Bovine Muscle

Curtis Lynn Kastner and R. L. Henrickson

The "hot" boning of bovine carcasses has received limited study, but "hot" processing of porcine muscle has been studied in detail. Processing of pork prior to chilling has proven advantageous; thus, it was hypothesized that the bovine carcass would also lend itself well to "hot" boning. Six Hereford steer carcass were assigned to each holding period. Each carcass was split and one side was "hot" boned while the other side was "cold" boned. Three post-mortem holding periods (two, five, and eight hours) for the "hot" boned sides were compared to a 48 hour conditioning period for the "cold" boned sides. Muscle quality and yield were compared for "hot" versus "cold" boning.

Yield was significantly less for "hot" boning as compared to the control in both the five and eight hour holding periods. The muscle moisture and fat percentages for "hot" and "cold" boning were not significantly different for all holding periods. The pressed fluid ratio was smaller for "hot" than "cold" boning in the two hour holding period, but the "hot" boned pressed fluid ratios were larger than the control in the five and eight hour holding periods.

Shear forces were statistically greater for "hot" boning than the control in the two and five hour holding periods, but conditioning for eight hours produced a non-significant difference in shear force for "hot" versus "cold" boning. Significant differences in color value scores for "hot" and "cold" boning were found for all holding periods. Even though significant color value differences were reported a color panel only detected the color difference between "hot" and "cold" boning in the two hour holding period.

A taste panel could not detect significant differences in flavor between "hot" and "cold" boning in all conditioning periods. Cooking loss percentages were not significantly different between "hot" boning and the control for each holding period. If muscles are excised "hot" at five to eight hours post-mortem, then "hot" boning is feasible considering the parameters evaluated in this study.

Procedure For Live Biopsy of Bovine Longissimus Dorsi Muscle

J. J. Guenther, T. R. Thedford and E. W. Jones

To study certain biochemical, physiological or structural characteristics of bovine muscle it is often necessary to obtain muscle samples from the live animal at various periods during the animal's growth cycle. The procedure to follow was developed to satisfy this need. (Note: As the longissimus dorsi is a convenient muscle to utilize in studies of this nature, the procedure is written for that muscle. However, it may be applied to other muscles as well.)

Preparation For Surgery

The animal is restrained either manually or via a squeeze chute. Clip or shave hair from area to be sampled. The T_{12} to L_4 area of the L dorsi is a desirable sampling area. Cleanse area by washing with surgical soap, alcohol and finally, iodine.

Anesthesia

Five milligrams per pound of body weight of Surital[R] are injected intravenous via the jugular vein. Concentration of the solution is 10 percent, primarily due to ease of injecting. The anesthesia should be given rapidly. Surgical anesthesia is attained in 1-1.5 minutes and will be maintained about 10-15 minutes. The animal will normally be able to sit up in about 20-25 minutes after anesthetizing and should be placed on its sternum at this time. The animals will be able to stand in about 35-45 minutes. (Note: Any additional administration of the drug should be made cautiously and experienced personnel should be on hand to revive animal.) Animals should be off feed 24 hours prior to anesthesia.

Surgery

A lateral incision through the skin, about 10 cm., is made, transverse to the muscle. The fascia and fat are not disturbed. Skin is retracted via allis tissue forceps to allow admission of biopsy device. Biopsy device consists of a stainless steel corer powered by an electric hand drill. A 1.0-2.5 cm. diameter corer is used, depending upon sample size desired. The corer is admitted slowly, but steadily, to deep border of muscle. Curved scissors are employed to clip sample at deep end. Wound is dust-ed with Furacin[R]. Closure is made with 3 vertical mattress sutures of Vetafil. Sutures should be removed 10-14 days post-surgery.

All instruments, including the stainless steel corer are sanitized by autoclaving, then stored in a 1-4000 solution of nolvalsan. The biopsy size is normally 10-15 grams. Animals slaughtered 4 weeks post-surgery show almost complete tissue recovery.

Swine

The Effect of Ration Ingredient Change on Pig Performance

W. G. Luce and C. V. Maxwell

Two trials have been conducted involving 128 growing-finishing swine to measure the effect of ration ingredient change on pig performance.

Treatments involved in both trials were (1) a basal milo-soybean meal ration fed throughout the trials; (2) the cereal grain portion of the rations (milo, corn, and wheat) was rotated every 7 days; (3) the protein source (all soybean meal, ⅓ meat and bone scraps and ⅔ soybean meal, and ⅓ peanut meal and ⅔ soybean meal) was rotated every 7 days; (4) both the cereal grain and protein sources, as outlined in Treatments 2 and 3, were rotated every 7 days (9 different combinations). Average daily gains, average daily feed intake, feed efficiency, and probed backfat thickness appeared to be similar for all treatments.

The data are presently being analyzed further and will be published at a later date.

Genetic Evaluation Of Purebred And Crossbred Performance For Three Breeds of Swine

I. T. Omtvedt, R. K. Johnson, C. E. Addison, Steve Welty and Tom Williams

A total of 182 litters were produced at Fort Reno during 1971 to evaluate the differences between purebreds and 2-breed crosses. Two papers are included in this publication giving the results obtained thus far. Feedlot performance and carcass data were available for only the spring pig crop, but both spring and fall farrowed litters were included in the productivity study. Although this phase of Project 1444 will be repeated during 1973 and the data now available are too limited to make many definite conclusions regarding differences in combining ability among Durocs, Hampshires and Yorkshires, marked increases in productivity were realized when Duroc and Hampshire gilts were mated to boars of different breeds to produce 2-breed cross litters.

During the winter of 1971, 210 purebred and 2-breed cross gilts were mated to produce 2-breed and 3-breed cross litters. One-third of these gilts were slaughtered 30 days after breeding to evaluate differences in ovulation rate and early embryo development. The remainder of the gilts will start farrowing in March. Another group of purebred and 2-breed cross gilts will be selected from the fall 1971 pig crop and bred during May and June to produce 2-breed and 3-breed cross litters in the fall. These matings will provide information on differences between purebred and crossbred dams and between 2-breed and 3-breed cross pigs, and information on the importance of maternal influence in determining the recommended crossing sequence.

In this project all the purebred boars and gilts used to produce the purebred and 2-breed cross litters at Fort Reno come from the seedstock herds at the Experimental Swine Farm at Stillwater. New bloodlines and rigid selection was practiced during 1971 to keep the genetic base as broad as possible and to change the composition of the herds. Eight boars and 54 gilts from each of these three breeds will be selected and taken to Fort Reno from each of the two farrowings in 1972.

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Dairy

Feed Flavors In Milk

M. S. Borges, O. P. Pryor and J. B. Mickle

Undesirable flavors in milk cause large monetary losses to Oklahoma dairy farmers each year. Among the most prevalent of these are feed flavors (including those caused by wheat pastures), oxidation (often called flat, cardboard, or metallic), and rancidity (called fishy or bitter). Lipase, an enzyme present in cows' blood and milk, has long been thought to cause rancid flavors; and recent evidence in the literature indicates that this enzyme might also be related to oxidized flavor and perhaps to feed flavors as well (1).

The purpose of the present study was to relate changes in the energy level of a cow's feed to the lipase activity in her milk. These feed changes also were studied in relation to changes in the charge on the milk proteins as measured by fractionation on DEAE cellulose. In preliminary work involving one Holstein cow, the animal first was fed a ration calculated at 100 percent of her "normal" energy requirements according to Morrison's Standards in a restricted roughage ration. This ration consisted of 28 lb of concentrate and 15 lb of average quality alfalfa hay. After two weeks, the cow was changed to a "maintenance" ration containing about 60 percent of her energy requirements. This ration consisted of 16 lb of concentrate and 20 lb of hay. After about three weeks on this ration, the milk developed a strong odor with a flavor sometimes described as "oxidized" and at other times as "strong feed." During this time, lipase activity in the milk decreased from 3.4 to 1.7 units per ml; and the charge on the separable proteins changed markedly—compare Figures 1 and 2.

The cow's ration then was increased, and she was allowed to eat as much as she wanted—which consisted of approximately 32 lb of concentrate and 20 lb of hay—or about 120 percent of her normal energy requirements. After the change, the protein pattern of the milk changed immediately (Figure 3), but the undesirable flavors persisted for 24

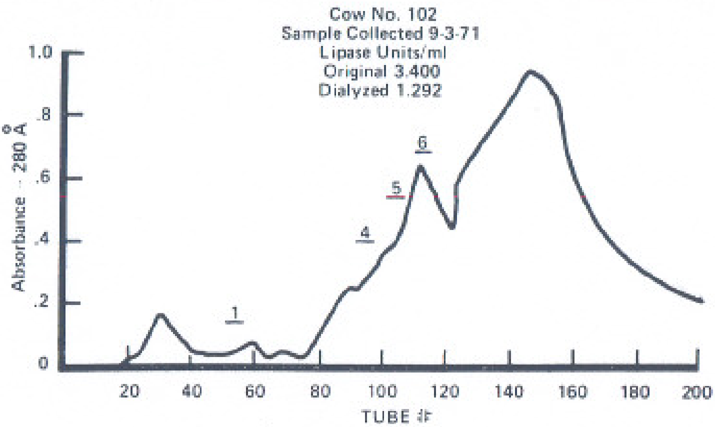

Figure 1. Chromatograph of milk protein on DEAE cellulose when Holstein Cow 102 was on a "normal" ration.

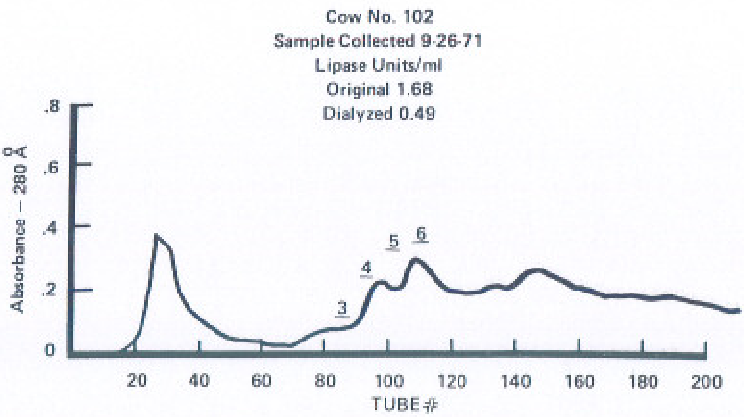

Figure 2. Chromatograph of milk protein on DEAE cellulose after Holstein Cow 102 had been on a "maintenance" ration for 24 days.

hours. After 48 hours, the protein patterns of the milk were back to normal, and the undesirable flavors had disappeared (Figure 4). Later work indicated that undesirable milk flavors were often associated with a change in energy level of the ration rather than with the composition

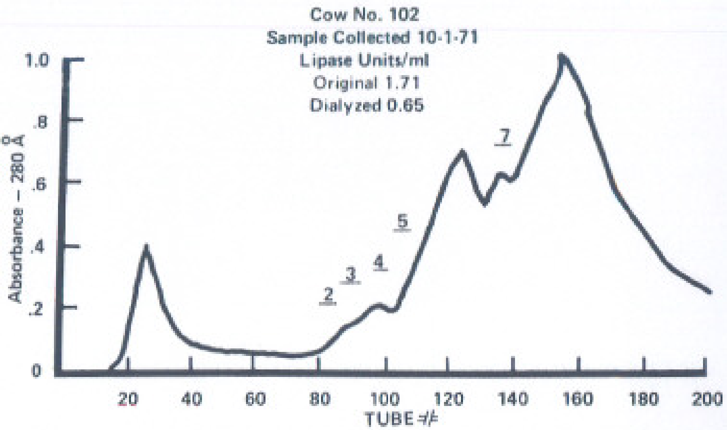

Figure 3. Chromatoggraph of milk protein on DEAE cellulose the day that Holstein Cow 102 was changed from a maintenance ration (60 percent ofnormal) to one containing 120 percent of the energy in a normal ration.

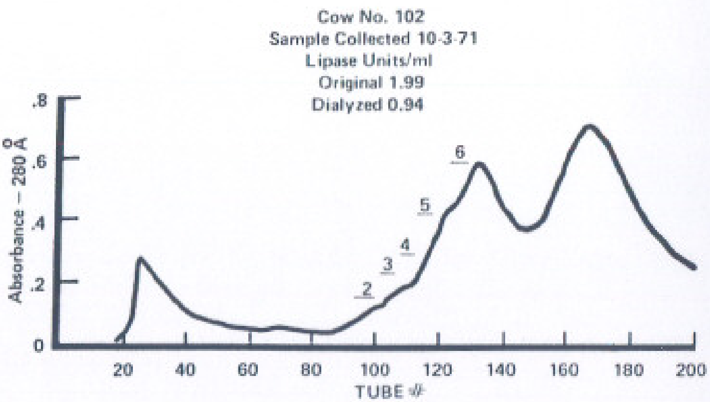

Figure 4. Chromatograph of milk protein on DEAE cellulose 48 hours after Holstein Cow 102 had been on a ration containing 120 percent of the energy in a normal ration.

of the ration itself. This work is continuing using other cows in an effort to learn more about the exact causes of these undesirable flavor changes in milk.

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Emulsifiers In Foods

J. B. Mickle

The studies concerning emulsifiers in foods at Oklahoma State University have developed several new food products during the last decade. These include low calorie spreads as well as solid and liquid cake shortenings. At present the research is aimed at developing a new type of candy base incorporating milk products.

Candy products are now on the market which can be used as bases for fudge-type candies. These bases contain all the ingredients necessary for this type of candy except the flavoring—the nuts or chocolate, etc. However, the products presently on the market do not include milk fat or any other milk ingredient.

Current research is aimed at determining the proper ingredient ratios using milk powder and fat together with the appropriate processing temperatures for the product. Emulsifiers appear to improve the texture of the candy, though there are problems with flavor; and the optimum amounts of these ingredients have yet to be worked out. It will be necessary to study the flavor, texture, and hardness of these products under various storage conditions over a period of time before it can be determined whether this type of candy base has commercial applicability.

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