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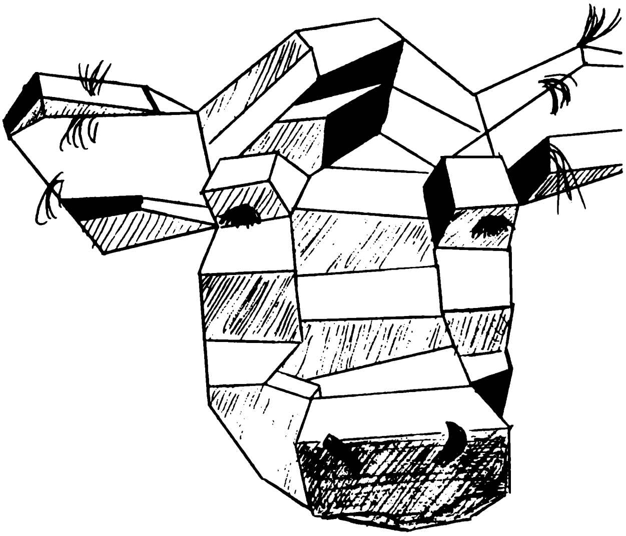

LIVESTOCK RESEARCH REPORT

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LIVESTOCK RESEARCH

REPORT

BY

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ANIMAL SCIENCE DEPARTMENT

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RUMINANT NUTRITION

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THE EFFECTS OF HIGH TRIS, LOW GLYCEROL AND LOW TRIS, HIGH GLYCEROL ON FROZEN RAM SPERMATOZOA

J. E. Parks and T. N. Meacham

A relationship between intact acrosomes and fertility in the bovine has been previously reported. It has been projected that a low Tris, high glycerol extender for ram semen preserved the highest percentage of acrosomes immediately post-thaw; but a high Tris, low glycerol medium maintained the acrosome better over a nine hour post-thaw incubation.

A fertility trial was designed to determine which of these two conditions was preferable for freezing ram semen for artificial insemination.

Experimental Procedure

Four ejaculates were collected from three Finnish-Landrace cross rams and one Hampshire ram with an artificial vagina. Once collected, the semen was held in a 32 C water bath until diluted. The extenders contained 20% fresh egg yolks by volume and 80% buffer composed of Tris(hydroxymethyl) aminomethane in distilled water. The pH was adjusted to 6.5 with citric acid monohydrate. Antibiotics were added to the diluted semen. The semen was initially diluted in fraction "A" which contained no glycerol. The partially diluted semen was cooled to 5 C in 2.5 hours. Once cooled, the semen was further extended in fraction "B" (glycerol fraction) to a final concentration of 50 x 10^6 sperm/ml. Fraction "B" was added at 10, 20, 30 and 40% by volume at 10 minute intervals to prevent osmotic shock to the sperm. Once glycerolated, the semen was drawn into .25 ml French straws, frozen in N_2 vapor in seven minutes and stored in liquid N_2.

A fertility trial was conducted on 65 ewes using the two treatments of frozen semen. Treatment I included .5 M Tris, 1% glycerol, and Treatment II contained .3 M Tris, 4% glycerol. Semen was evaluated immediately post-thaw and after 3, 6, and 9 hours of incubation at 37 C. Evaluation consisted of direct sperm counts of intact acrosomes using differential interference using phase contrast. Semen was thawed at 50 C and inseminated into estrus-synchronized ewes. Estrus was detected with four vasectomized marker rams. Ewes which returned to the heat subsequent to the initial insemination were inseminated a second time.

Results

Means for percent motility and intact acrosomes over nine hours of incubation appear in Table 1. Motility and intact acrosomes were higher for Treatment II, motility being zero for Treatment I throughout incubation. A highly significant interaction ($P<.002$) existed between treatments and hours of incubation on percent intact acrosomes. These values are presented in Table 2. Treatment II maintained a higher percentage of intact acrosomes throughout the incubation period. However, the rate of acrosomal deterioration was greater in Treatment II than in Treatment I over the nine hour incubation. Intact acrosomes decreased 17 percent in Treatment II ($P<.05$), but there was no significant decline in Treatment I. Significant interactions also existed between rams and hours of incubation, and between rams and treatments, which probably contributed to the interaction between treatments and hours of incubation.

Unfortunately, none of the 65 ewes inseminated became pregnant. Poor fertility with frozen ram semen is not uncommon, but a conception rate of zero is difficult to explain. Sperm numbers per insemination may have been too low for good conception in estrus synchronized ewes. Copious secretions were noted at the synchronized estrus which probably had a dilution effect and hindered sperm transport. Freeze-thaw conditions employed were considered optimum for the .5 ml French straw. Use of the .25 ml straw may have altered the response of the spermatozoa.

TABLE 1. EFFECTS OF GLYCEROL LEVEL AND TRIS MOLARITY ON MOTILITY AND INTACT ACROSOMES OVER NINE HOURS INCUBATION AT 37 C

Treatment	% Intact Acrosomes	% Motility
I - 1% glycerol, .5 M Tris	45.72	0
II - 4% glycerol, .3 M Tris	59.97**	30**

** P<.0001

TABLE 2. EFFECT OF TREATMENTS AND HOURS OF INCUBATION ON PERCENT INTACT ACROSOMES

	Hours of Incubation			
Treatment	0	3	6	9
I - 1% glycerol, .5 M Tris	48.75^{a}	47.88^{a}	43.50^{a}	42.75^{a}
II - 4% glycerol, .3 M Tris	70.38^{a}	60.25^{ab}	55.88^{b}	53.38^{b}

[a,b] Any superscript not on two values in the same row are significantly different (P<.05).

SCROTAL CIRCUMFERENCE AND TESTICULAR CONSISTENCY IN BEEF BULLS

J. L. Hutton, T. N. Meacham and A. L. Eller, Jr.

The demand for semen from sires with desirable economic characteristics has increased with the development of large A.I. organizations and the use of frozen semen. The economic situation of today's cattle business makes it imperative that the greatest number of sperm cells be harvested and the greatest number of calves be sired by these potentially superior bulls. Most potential herd sires are purchased when they possess only a fraction of their semen production potential. Their sperm production capacity must be estimated rather than measured. Previous research indicates scrotal circumference (scrot) and testicular consistency (tone) to be good parameters for estimating sperm production potential.

Experimental Procedures

Five hundred and eighty-five beef bulls ranging in age from 306 to 529 days were measured at four test stations in Virginia and at the Wardensville station in West Virginia. There were 295 Angus, 16 Hereford, 16 Red Angus, 91 Simmental, 2 Limousin, 38 Charolais, 2 Brangus and 125 Polled Herefords. Scrot was measured with a circular tape at the largest part of the scrotum, and tone was measured at the same place with a standard tonometer.

Initial measurements were taken several times until a high repeatability was achieved. Thereafter, scrot was measured once and tone was measured on each teste and averaged.

These measurements were compared with adjusted 205-day weight, final weight, average daily gain, adjusted 365-day weight, weight per day of age, and age in days for breeds and age groups within breeds to attempt to correlate scrot and tone with performance. Bulls 300 days or less were Age Group 1. Thereafter, they were broken into 30-day groups and numbered consecutively to 510 days. All bulls 510 days or older were put in Age Group 8. Regression models containing terms associated with desired comparisons and expected sources of variation were used to analyze the data.

Results

A breed effect was noted and breeds were analyzed individually. The Hereford, Red Angus, Limousin and Brangus breeds had insufficient numbers to gain accurate data. Angus, Simmental, Charolais and Polled Hereford breeds were compared for scrot and tone. Angus and Simmental had higher scrot values at all ages than did Charolais and Polled Hereford. However, each showed the same trends as shown in Table 1.

Age and final weight showed direct correlation with scrot and performance data accounting for 22-55% of scrot variation. In analysis of variance, age and final weight had the only significant effects on scrot ($P<.05$).

Changes in tone values could not be explained and seemed unrelated to any data studied.

Conclusions and Recommendations

Average scrot and tone are given for bulls of these four breeds by age groups in Table 1. These data suggest that any bull falling two standard deviations or more below these predicted values may have a sub-normal potential sperm production and should be culled.

TABLE 1. SCROTAL CIRCUMFERENCE AND TESTICULAR TONE BY BREED AND AGE GROUP

Age Group	Number	Scrot	Number	Tone
		ANGUS		
1	4	12.19 ± 1.31	4	.95 ± .06
2	71	12.89 ± 1.10	71	.96 ± .12
3	82	13.32 ± .97	81	.94 ± .11
4	56	13.91 ± .93	42	.95 ± .11
5	50	14.20 ± 1.21	36	.93 ± .08
6	18	14.20 ± .91	13	.94 ± .07
7	7	14.43 ± 1.42	6	.90 ± .09
8	7	14.46 ± .53	7	.87 ± .08
		SIMMENTAL		
1	17	12.37 ± .90	17	.97 ± .08
2	40	13.08 ± .95	40	.97 ± .09
3	15	13.72 ± 1.04	15	.91 ± .11
4	9	13.92 ± 1.52	9	.97 ± .17
5	4	14.44 ± 1.74	4	.88 ± .05
6	5	14.35 ± .85	5	.96 ± .11
7	0			
8	0			
		CHAROLAIS		
1	1	11.75 ± 0	1	1.0 ± 0
2	14	11.54 ± 1.26	14	.90 ± .15
3	7	11.93 ± 1.69	7	.83 ± .16
4	6	13.29 ± 1.05	6	.98 ± .12
5	9	14.0 ± 1.37	9	.88 ± .15
6	0			
7	0			
8	0			
		POLLED HEREFORD		
1	1	11.75 ± 0	1	1.0 ± 0
2	15	12.27 ± .84	15	.93 ± 1.0
3	20	12.50 ± 1.08	20	.93 ± .12
4	28	12.88 ± 1.06	22	.92 ± .12
5	31	13.48 ± .89	15	.94 ± .12
6	14	13.45 ± .72	11	.91 ± .11
7	12	13.23 ± .93	11	.94 ± .14
8	4	13.00 ± 1.38	4	.88 ± .13

MANAGEMENT SYSTEMS FOR EWES AND LAMBS

W. H. McClure, G. A. Allen, Jr., R. E. Blaser, J. P. Fontenot and J. M. Moore

For a number of years sheep research and on-farm production in Virginia has tended to become more intensified. Such practices as early weaning and multiple lambing have been common. Because of rising feed costs and greater labor requirements, there may be justification for considering the use of extensive production systems requiring less feed and labor and making more use of available winter forages.

A long-term ewe and lamb management systems experiment was initiated at the Shenandoah Valley Research Station in the spring of 1974 to study the comparative merits of fall, winter and spring lambing and various management practices for ewes and lambs as related to these lambing dates. The 225 ewes used in the project were all sired by Suffolk rams and basically out of black-face type western ewes.

Experimental Procedure

The following is a basic outline that will be used for the test:

TREATMENT 1-A - 150 Ewes

Pre-Breeding:	Vasectomized rams turned in May 1 to May 20.
Breeding Dates:	May 20 to June 25. Four Suffolk and 2 Dorset rams to be used.
Pre-Lambing Management:	Ewes on good summer and fall pasture, plus 1/2 lb. grain per head daily, 2 weeks before lambing. Ewes diagnosed carrying twins will be fed .75 lb. grain per day.
Lambing Dates:	October 15 - November 20 - Ewes will be lambed on pasture.
Post-Lambing Management:	All ewes to be put on permanent or native pasture until Nov. 1.

After November 1:

1. Ewes will graze on stock piled and fed fescue, 1 lb. grain per ewe daily and lambs creep fed.
2. Ewes to graze fescue and lambs creep fed. (Ewes to be supplemented with good quality hay when snow covers ground.)

3. Conventional Management:
Good quality hay, plus 1 lb. grain per ewe daily and creep for lambs.

Weaning Age: 90 days.

Post-Weaning Management:
1. Top quality corn silage + corn at level of 2% body weight + supplement.
2. Standard, 25% hay and 75% concentrate ground ration, self fed.

TREATMENT 1-B

All ewes will be pregnancy checked just prior to Sept. 1. Ewes not bred will be re-exposed to rams.

Pre-Breeding: Vasectomized rams to be used Aug. 1 - Sept. 1.

Breeding Dates: Sept. 1 - Oct. 25. Suffolk and Dorset rams to be used.

Pre-Lambing Management:
1. Graze on fescue pasture.
2. Native pasture plus hay to be supplemented with 1/2 lb. grain for all ewes 30 days before lambing and 1 lb. grain 15 days before lambing.

Lambing Dates: Jan. 25 - Mar. 1

Post-Lambing Management:
1. Fescue grazing plus 1 lb. grain per ewe daily and creep for lambs.
2. Small grain pasture and creep for lambs. (Ewes will be supplemented with good quality hay when snow covers ground.)
3. Conventional Management:
Good quality hay plus 1 lb. grain per ewe daily and creep for lambs.

All ewes will be grazed on spring pasture between Apr. 20 and May 1.

Weaning Date: June 15.

Post Weaning Management:
1. Grain on grass
2. Pasture
3. Dry lot

TREATMENT 2 - 75 Ewes

Pre-Breeding: Vasectomized rams to be used, October 10 - November 1.

Breeding Dates: Nov. 1 - Dec. 5 - Suffolk and Dorset rams to be used.

<u>Pre-Lambing Management</u>:	1. Fescue pasture 2. Native pasture and good second cutting hay 3. Small grain pasture and average quality hay	All treatments will receive hay when snow covers pasture.

All ewes will get 1/2 lb. grain 30 days before lambing and 1 lb. grain 15 days before lambing.

<u>Lambing Dates</u>: Mar. 25 - May 1. Lambing on pasture.

<u>Post-Lambing Management</u>:
1. Fescue grazing until Apr. 20 and creep for lambs.
2. Conventional Management: Good quality hay plus 1 lb. grain per ewe daily and creep for lambs.

After Apr. 20, all ewes and lambs will be grazed on spring pasture.

<u>Weaning Age</u>: 120 days

<u>Post-Weaning Management</u>:
1. Dry lot
2. Grain on grass
3. Grass

Results

Results of the first year's tests are incomplete. The tests started in May, 1974 when 140 ewes were turned out for 35 days with rams. Of this number, 30 of the ewes lambed and raised 28 lambs for a 93% lamb crop. The remainder of these ewes were turned out with rams again on Sept. 1, and 91 ewes lambed beginning in late January. These 91 ewes are raising 151 lambs for a 165% lamb crop. The spring lambing ewes were turned in with rams on Nov. 1, with 76 ewes having 129 lambs alive at 36 hr. after birth for a 169% lamb crop.

There are indications that the ewes and lambs grazed on winter pastures compared favorably in every way with control ewes and lambs handled by conventional methods. The lambs from the fall lambing system were weaned Feb. 14, 1975 and the first ones were marketed on Apr. 15.

Preliminary results indicate that ewes of the type used in this test will be difficult to breed in May for fall lambing, and will have fewer multiple births than ewes bred for mid-winter or spring lambing. The fall born lambs performed well both before and after weaning. Fescue and small grain pasture can definitely be used to an economical advantage for ewes lambing during each of the three seasons.

PERFORMANCE OF LAMBS WEANED AT DIFFERENT WEIGHTS

W. H. McClure, R. C. Carter, J. P. Fontenot and H. D. Hupp

For a number of years Virginia's Research Stations have placed special emphasis on developing rations and systems of either weaning lambs early or late, and then feeding them in confinement to an optimum market weight. In view of the sharp increases in the cost of ingredients utilized in the rations, these systems of growing lambs must be reevaluated from the standpoint of economy and efficiency of gain. Trials were conducted at the Shenandoah Valley Research Station at Steeles Tavern in 1973 and 1974 to study the daily gain and efficiency of lambs weaned at different weights and fed in confinement to market weight.

Experimental Procedure

The lambs used in this study were sired by purebred Hampshire rams and were out of Suffolk-Rambouillet crossbred ewes. The average lambing dates were January 28, 1973 and February 7, 1974. All lambs were creep fed until weaning. At approximately 14 days of age, all lambs were vaccinated against enterotoxemia, docked and ram lambs were castrated.

Just prior to the beginning of the trial, the lambs were vaccinated again for enterotoxemia, injected intramuscularly with a combination of selenium and vitamin E to prevent stiff lamb disease, and treated for internal parasites.

Table 1 shows the characteristics of the lambs used in 1973. In that year, 175 lambs were weaned on April 24 with ages ranging from 60 to 112 days and weights from 30 to 80 lb. Lambs were assigned to four lots, based on weight alone, with no consideration given to sex, age, sire or type of birth and rearing. The average initial weights of lots 1, 2, 3 and 4 were 35, 45, 55, 67 lb., respectively. The lots with the lighter weights also had lower weight per day of age and contained younger animals. Lots 1 and 2 had a higher percentage of twins, 65 and 53%, than lots 3 and 4. Lots 3 and 4 had a higher percentage of singles and twins raised as singles, 64% (52 + 12) and 98% (96 + 2).

The characteristics of the lambs used in 1974 are presented in table 2. The 212 lambs used in 1974 were weaned on May 7, and were assigned to lots again according to weights only. The average weights for lots 1, 2, 3 and 4 were 49, 58, 65 and 77 lb., respectively, averaging 12 lb. heavier than the previous year. Again, lots 1 and 2 had a higher percentage of twins, 89 and 93%, than in 1973. Lots 3 and 4, however, had a higher percentage of twins than 1973, 60 and 32%.

Combining the data from both years, lots 1 and 2 were significantly lighter, younger and had a lower weight per day of age than lot 3. Lot 3 was also significantly lighter and younger than lot 4.

Feed was weighed into the feeders daily in each lot, and weighed back every 14 days when the lambs were weighed. Lambs from each lot were removed for slaughter at 2-week intervals when they reached a minimum weight of 96 lb.

Table 3 presents the average composition of rations used in both years. The pelleted ration used during the feeding trial was substituted for the creep rations for 2 weeks prior to weaning. The ingredient composition of the ration was the same for both years, except soybean meal was used only in 1973, and urea and cottonseed meal were used only in 1974. The proportions presented in this table are in terms of a 1,000 pound batch of feed. Lambs were placed on expanded metal floors and allowed to eat the pelleted rations _ad libitum_. Trace mineralized salt was fed free choice.

Results and Discussion

Two analyses were used. The first one was on lot means adjusted for sex only; and the second was on lot means adjusted for both sex and type of birth and rearing.

Table 4 presents means adjusted for sex for both years combined. There was a highly significant ($P < .01$) linear decrease in age at the end of the test from 179 days for lot 1 through 135 days for lot 4, for a difference of 44 days. Since the lambs that were younger initially were on test longer, they consequently had later final dates. The average final dates ranged from August 4 for lot 1 through June 10 for lot 4, a difference of 55 days.

Since all lambs were removed at a constant weight there were no differences in final weight. Since weight was held constant, the only variable was time on test. The lambs that were younger at the beginning of the test gained the most on test, ranging from a high of 56 lb. for lot 1 to 29 lb. for lot 4. All differences were significant. This is due, of course, to the difference in the initial weight and age. There was a significant increase in daily gains as final age decreased. This should indicate that the heavier lambs at the beginning of the test gained much faster than the lighter lambs. The differences in feed/gain ratio were non-significant although there was a trend for heavier lambs to be more efficient in feed conversion. Along with final weight, there were no significant trends or differences for live grade.

Table 5 presents the means when they were adjusted for both sex and type of birth and rearing. When this adjustment was made, the same trends were observed. Again, there was a significant linear trend for final age, with the significant differences being limited to lot 1 _vs_. lots 3 and 4, and lot 2 vs. lot 4. The differences for final age between lots 1 and 4 (July 30 - June 7) was 53 days. Again, there was an obvious trend for the younger lambs at the beginning of the test to have larger total gains, but lower daily gains on test. The significant differences for daily gain were limited to lots 1 and 2 vs. lots 3 and 4. Again, there were no significant trends or differences for feed/gain ratio or live grade.

Summary

From these data, the lighter lambs were significantly younger and had significantly lower weight per day age going on test and consequently gained more and were on test longer than heavier lambs. The lighter lambs had lower daily gains over the whole test than did the heavier lambs which would imply that the daily gain decreased as the length of time on test increased, which would be a reflection of the warmer weather in mid to late summer.

The heavier lambs going on test had higher daily gains and consequently gained faster on test. These lambs reached market weight averaging 30 days younger and 25 days sooner than the lighter lambs. There was a small non-significant trend for the heavier lambs to have a better feed/gain ratio over the whole test.

Since lambs were removed at a constant weight there were no differences for final weight nor live grade. Both types of adjustments to lot means yielded the same results.

TABLE 1. CHARACTERISTICS OF LAMBS USED ON TEST IN 1973

Parameter	Lot 1	Lot 2	Lot 3	Lot 4
No. of lambs	42	41	47	45
Initial wt., lb.	35.3	45.1	55.1	66.8
Wt/day of age, initial, lb.	0.43	0.53	0.63	0.72
Average age, days	83.8	86.9	88.1	93.1
Singles, %	21	28	52	96
Twins, %	65	53	36	2
Twins raised as singles, %	14	19	12	2

TABLE 2. CHARACTERISTICS OF LAMBS USED ON TEST IN 1974

Parameter	Lot 1	Lot 2	Lot 3	Lot 4
No. of lambs	55	55	52	50
Initial wt., lb.	49.2	57.7	65.0	77.2
Wt/day of age, initial, lb.	0.66	0.67	0.70	0.82
Average age, days	82.7	87.3	93.9	94.4
Singles, %	4	11	25	56
Twins, %	89	83	60	32
Twins raised as singles, %	7	6	15	12

TABLE 3. COMPOSITION OF PELLETED RATIONS[a]

Ingredients	1973	1974
Ground ear corn	859	848
Soybean meal (50% protein)	70	-
Fish meal (70% protein)	50	50
Limestone	10	10
Fat	5	5
Salt	5	5
Antibiotic premix	1	1
Urea	-	6
Cottonseed meal	-	75
Total	1,000	1,000

[a]Vitamin addition: 600,000 I.U. vitamin A, 50,000 I.U. vitamin E and 60,000 I.U. vitamin D per 1,000 lb. ration.

TABLE 4. MEANS ADJUSTED FOR SEX FOR BOTH YEARS

Parameter	Lot 1	Lot 2	Lot 3	Lot 4
Age, end of test, days	179	163	148	135
Final date	Aug. 4	July 15	June 25	June 10
Final wt., lb.	97.9	98.4	99.1	102.1
Gain/lamb, lb.	55.9	47.0	39.1	29.0
Daily gain, lb.	.59	.62	.69	.74
Feed/gain, lb.	4.37	4.46	4.23	4.31
Live grade[a]	15.3	14.9	15.4	15.0

[a]Code: 14=high choice; 15=low prime; 16=prime.

TABLE 5. MEANS ADJUSTED FOR SEX AND TYPE OF BIRTH AND REARING FOR BOTH YEARS

Trait	Lot 1	Lot 2	Lot 3	Lot 4
Age, end of test, days	175	160	146	135
Final date	July 30	July 11	June 21	June 7
Final wt., lb.	98.9	99.5	100.1	103.1
Gain/lamb, lb.	55.1	46.7	38.7	28.7
Daily gain, lb.	.59	.62	.69	.73
Feed/gain, lb.	4.47	4.49	4.26	4.43
Live grade[a]	15.3	14.9	15.4	15.1

[a]Code: 14=high choice; 15=low prime; 16=prime.

TWO LEVELS OF SUPPLEMENTAL PROTEIN FOR PERFORMANCE TESTING BULLS ON CORN SILAGE

G. L. Minish and B. R. McKinnon

Introduction

Procedures for 140-day tests vary greatly, especially the rations between stations and areas of the country. Virginia and similar states in the Southeast have an ample supply of roughage and limited grain. Most cattle are grown and many finished on high roughage rations. Accordingly, it only seems logical to test bulls on high roughage rations that relate to the environment to which they will be in service.

Bulls can be compared for growth potential as accurately if the test average daily gain is near 2.5 lb. per day as well as if the test average is near 3.0 lb. per day. In order to provide a reasonably high roughage ration and still produce these gains, corn silage appears logical to meet these requirements. It has been well documented that steers will average over 2.5 lb. gain per day on a full feed of corn silage plus 1.0% of their body weight as added concentrates. However, the optimum level of supplemental protein to corn silage rations for efficient and economical finishing and testing bulls has not been established.

Against this background, it appears clear that research efforts are essential to establish supplemental protein levels that are satisfactory to test bulls on high silage rations. This project was designed to compare differences between two supplemental protein levels on high silage rations for 140-day bull feed tests. The two levels of protein basically represent treatment rations. The supplemental protein levels are held constant throughout the test and in essence the crude protein percentage of the rations declines from the beginning to end of the 84 days while the energy content of the rations and maturity of the bulls increased.

Procedure

Research was conducted on bulls from the V.P.I. & S.U. teaching and research herds. Twenty-four bull calves of various breeds ranging in age from 180 to 260 days were weaned and allotted as evenly as possible for weight, breed, and age to the two following ration treatments: Treatment I consisted of a full-feed of corn silage, 1.0 lb. of cracked corn per 100 lbs.of body weight, and 2.0 lbs. of supplement per head per day consisting of 1.0 lb. of 44% soybean oil meal and 1.0 lb. of cracked corn and 30,000 I.U.'s of Vitamin A. Treatment II received a full-feed of corn silage, 1.0 lb. of cracked corn per 100 lbs. of body wieght, and 2.0 lbs. of supplement consisting of 44% soybean oil meal and 30,000 I.U.'s of Vitamin A. Both treatments were provided a free choice salt-mineral mix of one part trace mineralized salt, one part ground limestone and one part de-flourinated rock phosphate.

There was a 21-day adjustment period on each ration prior to the beginning of the test. The length of the official feed test was 84 days. Bulls were weighed and measured every 28 days while on test, and average daily gains, height at the withers, height at rump, body length from the point of shoulder to the pin bone, and length of cannon data were collected. All of the feeds were analyzed by proximate analysis. The corn silage was sampled weekly. The protein supplements and cracked corn were smapled at each feeding and collected for each 28-day period.

Results

Because of high moisture content in the corn silage, the actual crude protein levels of the rations were slightly lower than initially planned. Feed and weight gain data are presented in Table 1.

Weight gains and increases in body measurements were used to evaluate the relative effectiveness of the two rations. The bulls in Treatment II (13% C.P.) showed significantly ($P<.005$) greater average daily gains than those in Treatment I (11% C.P.). Bulls in Treatment II also made larger increases in overall body length and withers height, ($P<.01$) and ($P<.025$), respectively. No significant differences among treatments were demonstrated for rump height or cannon length. Body measurement changes are shown in Table 2. Group feed conversion also favored the higher protein ration as shown in Table 1.

TABLE 1. WEIGHT GAIN PERFORMANCE ON BOTH RATIONS

	Treatment I (11% C.P.)				Treatment II (13% C.P.)			
	1st 28 Days	2nd 28 Days	3rd 28 Days	Avg.	1st 28 Days	2nd 28 Days	3rd 28 Days	Avg.
% Protein on Dry Matter Basis	10.36	10.64	10.75	10.58	12.57	12.44	12.33	12.45
Avg. Daily Dry Matter Consumption Per Head (lbs.)	16.2	16.8	16.9	16.6	17.2	18.2	18.4	17.9
Group Feed Conversion on Dry Matter Basis	6.490	6.455	7.442	6.796	5.274	5.828	6.016	5.706
Period Avg. Daily Gain (lbs.)	2.50	2.60	2.27	2.46	3.26	3.12	3.07	3.15
Cummulative Avg. Daily Gain (lbs.)	2.50	2.55	2.46[a]		3.26	3.19	3.15[a]	

[a] Treatment difference was significant (P<.005).

TABLE 2. BODY MEASUREMENT PERFORMANCE ON BOTH RATIONS

	Avg. Initial Measurements		Avg. 28-Day Measurements		Avg. 56-Day Measurements		Avg. 84-Day Measurements	
	Treat. I	Treat. II	Treat. I	Treat. II	Treat. I	Treat. II	Treat. I	Treat. II
Withers Height[a]	40.98	40.75	41.50	42.29	42.38	43.10	43.00	43.79
Rump Height	43.60	43.56	44.10	44.48	45.29	45.35	45.92	46.27
Overall Length[b]	47.08	46.96	48.88	49.50	50.44	50.92	50.42	52.42
Cannon Length	19.10	19.32	18.65	18.88	18.58	19.04	19.23	19.52

[a]Treatment differences in change from initial to 84-day measurements were significant ($P<.025$).

[b]Treatment differences in change from initial to 84-day measurements were significant ($P<.01$).

SYSTEMS OF FATTENING CATTLE IN SOUTHWEST VIRGINIA[1]

F. S. McClaugherty, J. P. Fontenot, R. F. Kelly, M. B. Wise and R. C. Carter

Within the past year there has been renewed interest in fattening cattle on forage with minimum or no grain supplementation. This has resulted in part from the high price of grain, relative to the price of cattle. Also, there is resistance to using large amounts of grain for feeding cattle in view of shortages of grain for human diets in some parts of the world.

Pastures in Southwest Virginia, which consist predominantly of bluegrass and white clover, are quite productive with good management and much of the land which is in pasture is too steep for cultivation. The pastures, although very productive in the spring, decline in forage quality and production in July. Thus, with a set stocking rate or with a constant management scheme, pastures are either understocked in the spring or overstocked in the summer.

It was shown in research at Glade Spring and at Blacksburg that pastures can be more fully utilized by stocking heavy in the spring and lighter in the summer. In previous research at the Southwest Research Station it was shown that heifers could be fattened to desirable finish by July with about one-half full feed of grain. Researchers in North Carolina have successfully fattened cattle on pasture with limited grain supplementation, and they found that including about 10% animal fat in the grain was a practical method to limit grain consumption of fattening cattle.

An experiment was conducted to test various systems of fattening cattle using predominantly native bluegrass pastures. The first two years' results from this experiment have been reported in previous Livestock Research Reports (V.P.I. & S.U. Res. Div. Rep. 153 and 158). A third trial was conducted during the past year and the results of this trial will be reported in this report, in addition to a summary of the first three years.

Experimental Procedure

Thirty-six yearling steers and 12 yearling heifers were used for this experiment. The cattle consisted of Angus, Shorthorn and crossbred cattle from different research stations in Virginia. The steers were allotted at random from groups of similar breeding and weight to pasture plots to receive the following treatments:

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[1]Animal fat was supplied by Valleydale Packers, Bristol, Va.

System 1 - Steers. These were grazed on .5 acre per steer with no supplemental grain until July 9. They were then fed in drylot a ration consisting of hay and limited grain. The cattle were slaughtered when they reached an average weight approaching 1100 lb.

System 2 - Steers. They were grazed on .5 acre per steer until July 9 and one acre per steer thereafter with no supplemental grain. On October 22 the steers were placed in drylot and fed a ration of hay and limited grain. The cattle were slaughtered when they reached an average weight of about 1050 lb.

System 3 - Steers. These were grazed on .5 acre per head until July 10 and one acre per head thereafter and were self-fed a mixture of 90% ground shelled corn and 10% animal fat. They were slaughtered at the end of the pasture season, October 22, 1974.

System 4 - Heifers. The heifers were allotted to two pastures, grazed on .5 acre per head and were self-fed a mixture of 90% ground shelled corn and 10% animal fat until they were slaughtered on July 9, 1974.

Results

The results of the 1974-75 trial are given in table 1. The heifers gained 2.40 lb. per head per day during the 84 days they were on test. The 10 lb. grain-fat consumed per head per day is somewhat more than 1% of bodyweight. The average carcass grade of the heifers is about average good.

The overall performance of the steers fed the grain-fat mixture during the entire grazing season was very good. The average daily gain was 2.96 lb. for the first 84 days and 2.56 lb. for the entire grazing season. The average grain consumption was 7.93, which is slightly less than 1% of bodyweight. The carcass grade of these cattle approached high good and the dressing percent was a very respectable 59%.

Average daily gains until July 10 for the steers which were fed no supplemental grain was approximately 1.8 lb. (Systems 1 and 2). These gains are lower than observed last year. The gains were lower after July 9 for the steers which remained on pasture (System 2). The average daily gain for the entire grazing season for these steers was 1.30 lb. These would have definitely been in too poor condition to slaughter at the end of the pasture season. The feedlot gain was somewhat better for the cattle on System 2 than for those on System 1. The carcass grade for both of these systems averaged top good with a dressing percent of 56.

The average results for the first 3 years of this experiment are shown in table 2. The average daily gain for the heifers during the three years was about 2.4 lb. per day and they consumed 9.6 lb. of grain-fat. The average carcass grade was average good.

The steers fed the grain-fat mixture performed consistently well during the three years, averaging 2.44 lb. per head per day during the entire grazing season on 10 lb. of grain-fat per day. The cattle on Systems 1 and 2 produced carcasses averaging between average and high good. The results of this experiment indicate that a variety of combinations of management systems can be effectively used for utilization of pastures for stocker and fattening cattle, producing fat cattle on a minimum amount of grain.

TABLE 1. MANAGEMENT SYSTEMS FOR FATTENING CATTLE 1974-75

	Steers			Heifers
	System 1	System 2	System 3	System 4
Initial wt., lb.	582	582	588	588
Wt., July 9, lb.	735	737	837	790
Daily gain, 84 days, lb.	1.82	1.84	2.96	2.40
Wt., Oct. 22, lb.	948	828	1072	
Daily gain, pasture, lb.		1.30	2.56	
Wt., end of feedlot period, lb.	1082	1051		
Daily gain in feedlot, lb.	2.17	2.37		
No. days on test	244	283	189	84
Grain-fat/day, lb.			7.93	10.00
Feedlot ration, lb./day				
Hay	12.9	12.8		
Grain	12.8	13.0		
Total feed consumption, lb./head				
Grain - fat			1499	842
Hay	2070	1200		
Shelled Corn	2055	1226		
Soybean meal	28			
Carcass grade[a]	10.9	10.8	10.7	9.8
Dressing %	56	56	59	56
Loin eye muscle area, sq. in.	12.0	10.6	11.5	9.3
Backfat, in.	.77	.67	.76	.47

[a]Carcass grade code: 9 = low good; 10 = average good; 11 = high good; etc.

TABLE 2. MANAGEMENT SYSTEMS FOR FATTENING CATTLE - THREE-YEAR AVERAGE

	Steers			Heifers
	System 1	System 2	System 3	System 4
Initial Wt., lb. (May 3)	609	619	605	585
Wt., July 12, lb.	731	745	802	751
Daily gain, 70 days, lb.	1.74	1.80	2.81	2.37
Wt., Oct. 18, lb.	920	827	1015	
Daily gain, pasture, lb.		1.24	2.44	
Wt., end of feedlot period, lb.	1043	1066		
Daily gain in feedlot, lb.	2.03	2.21		
No. days on test	224	276	168	70
Grain fat/day, lb.			10.0	9.6
Feedlot ration, lb./day				
Sil. (1972-1973)	31.7	29.0		
Grain (1972, 1973, 1974)	9.9	10.8		
Soybean meal (1972-1973)	2.0	2.0		
Hay (1974)	12.9	12.8		
Carcass grade[a]	10.8	10.6	10.4	9.9
Dressing %	56.8	56.9	57.9	55.9
Loin eye muscle area, sq. in.	11.4	11.1	10.7	9.2[b]
Backfat , in.	.69	.60	.65	.48[b]

[a]Carcass grade code: 9 = good; 10 = average good; 11 = high good; etc.
[b]Avg. for 2 yr.

SYSTEMS FOR WINTERING BEEF COWS[1]

W. H. McClure, J. P. Fontenot and T. N. Meacham

One of the most important problems facing Virginia cattlemen with beef cow and calf operations is that of reducing winter feed costs. Labor availability and cost and machinery cost are two major factors. Labor-saving practices for utilizing forages for wintering cows such as allowing the cows to graze the crop, are attractive, especially for small operations.

Some Virginia farmers have been utilizing tall fescue in a winter grazing scheme to reduce the amount of stored feed necessary to maintain a beef cow during the winter season. More recently, there has been a keen interest in utilizing tall forage sorghums as a winter grazing crop for beef cows. Although tall fescue and the tall forage sorghums have both been rather widely used for wintering beef cows, data on the economics of utilizing these forages, the short and long-term effects on the performance of the cows and their calves, or the need for protein supplementation are limited.

A long range experiment designed to study systems of managing beef cows during the winter season was initiated at the Shenandoah Valley Research Station during the winter of 1973-74 and continued during the winter of 1974-75.

Experimental Procedure

There are 125 cows involved in the trial. Ninety-five of these cows, from the long-term crossbreeding study, are Hereford, Angus, Shorthorn or 3-breed crosses between these breeds. All of the cows were diagnosed pregnant in October, 1973 to start calving in late January, 1974, and all cows are the same age. These cows were allotted at random into five treatment groups on the basis of type of breeding and weight, and remained in the same treatment groups for the 1974-75 test.

Thirty of the cows used in the test were sired by Charolais or Simmental bulls, and are of various ages and percentages of sire breed. The other breeds represented in these cows are Angus, Hereford, Shorthorn, Brown Swiss and Holstein. These cows were allotted at random, six to each treatment, on the basis of age, type and percentage breeding, and weight. Because of the poor breeding performance of some of these cows, some were culled after the 1973-74 trial and all were re-randomized to different treatment systems, beginning with the 1974-75 season.

[1]Liquid supplement was supplied by National Molasses Co., Willow Grove, Pa. and the tank by Augusta Cooperative Farm Bureau, Staunton, Va.
Biuret was provided by Dow Chemical Co., Midland, Mich. and mineral supplement by Southern States Cooperative, Richmond, Va.

The British breed cows in the study are all bred by natural mating, and the "exotic" crosses are bred artificially for spring calving. A bull was used for natural mating on these cows after several services artificially.

A brief description of the five systems, with 25 cows in each system, follows:

System I. Tall Forage Sorghum (15 acres) and Liquid Supplement. A popular commercial variety of male sterile forage sorghum was seeded in late June, in a plowed and prepared seed bed in 18-in. rows at the rate of 14 lb. of seed per acre. Fertilizer was applied initially in 1973 and again in 1974 at the rate of 140 lb. N, 80 lb. P_2O_5 and 80 lb. K/acre. A herbicide was incorporated with the nitrogen and applied to help provide weed and grass control. During the 1973 growing season the sorghum reached heights of 14 to 16 feet, but was somewhat shorter in 1974. The sorghum was allowed to frost and dry during the early winter, with moderate lodging occurring.

In addition to the 15-acre forage sorghum field, the cows had access to a small, partially wooded field with water during the test. Previous close fall grazing had removed most of the forage from this field each year. A liquid supplement dispenser equipped with lick wheels was placed in a convenient location in this field. The supplement contained about 32% crude protein. With the aid of an electric fence the field was divided into three parts and cows were forced to close graze each section before being turned in to a new section.

Some dry weather was experienced during the 1974 growing season, resulting in a much lower yield than that realized in 1973. It was estimated that each year about 94% of the forage in the field was consumed by the cows. During the first winter of the test the cows were turned into the sorghum on January 2 and remained until April 1 with no additional feed. During the 1974-75 season the cows were turned in on December 16 and by February 7 all the sorghum had been grazed and the cows were fed hay daily until the completion of the test on April 7. Cows were checked twice daily and all calves were identified and weighed at birth.

System II. Forage Sorghum (15 acres) and Biuret Supplement. Forage sorghum for this system was seeded at the same rate and in the same manner as for System I, with the same fertilization and herbicides. Forage yield checks showed the two fields to be quite similar in total forage available.

A small adjacent field with natural shelter and water was also provided for this system. A supplemental feeder box was placed at a convenient location and cows were given access to a dry supplement containing 50% biuret, 48.5% livestock mineral supplement and 1.5% sulphur, during the 1973-74 test. A mixture containing magnesium oxide was also fed to the cows free choice. For the 1974-75 test this supplement was changed to contain 43.5% biuret, 20% magnesium oxide, 20% livestock mineral supplement, 15% dry molasses and 1 1/2% sulphur. Consumption for the 1974-75 test was slightly better on a per cow basis.

Grazing dates for both years were the same as for System I, and the step-grazing system was used. The only physical difference between System I and System II was the source of nitrogen supplementation.

System III. Tall Fescue (15 acres) and Tall Sorghum (7.5) Acres. This system was designed to test the feasibility of using fescue and tall sorghum in combination. One possible theory that may make this system attractive is the possibility that cows could graze on the taller sorghum while snow covers the ground and fescue when the ground is clear.

The sorghum was seeded and managed exactly as in Systems I and II, except that cows were given access to the entire 7.5 acres throughout the test.

Part of the fescue was an old existing sod and part was seeded in the spring of 1973 at the rate of 15 lb. fescue, 2 lb. of red clover and 1 lb. of ladino clover per acre. At seeding time, fertilizeer was applied at the rate of 40 lb. N, 80 lb. P_2O_5 and 80 lb. K per acre. The old and new fescue was clipped closely about August 1, 1973 and August 1, 1974 and "stockpiled" until the test was started each year. Nitrogen was applied at the rate of 40 lb. per acre on fescue containing a good stand of clover and 100 lb. per acre where there was no clover.

The cows were turned in on January 2, 1974 and December 16, 1974 and handled exactly the same as the cows mentioned in the two previously discussed systems, except that no protein supplement was offered. The cows remained in the treatment until early April each year. A closely grazed accessory field with natural shelter and water was also provided for the cows in this system.

System IV. Control - Conventional Winter Management. The cows in this system were allowed to range on a 40-acre field of primarily bluegrass and orchardgrass sod with natural shelter and water. Because of excellent fall growing seasons and relatively mild winters, there was considerable aftermath grazing available for the cows in this system. The cows were fed 1800 lb. of hay each during the 1973-74 grazing season and 2422 lb. each during the 1974-75 season. The hay was average quality orchardgrass and red clover. Daily cow management was the same as for cows in the previously mentioned systems.

System V. Fescue (30 acres). The 25 cows in this system were grazed during the entire test period on tall fescue with no additional feed being fed during the 1973-74 test. There was more snow in 1974-75 and some hay was fed. The fescue was partly an old sod, and partly newly seeded in 1973. Fertilizatization and management were exactly the same as for the fescue used in System III. The cows in this system were handled in the same manner as cows in the other systems and remained on the pasture after the test was concluded each year without additional feed.

All cows were injected with 1,000,000 I.U. of vitamin A and 150,000 I.U. of vitamin D at the beginning of the trial and were sprayed for lice. All lots received a mixture of 1/3 salt, 1/3 steam bonemeal and 1/3 magnesium oxide, fed free choice, during the 1973-74 test; and cows in Systems I, III, IV and V received this mixture during the 1974-75 test.

Results and Discussion

Table 1 presents a composite chemical composition of the forages for the 2 years. Crude protein analysis clearly defines the need for additional protein supplementation for cows grazing the forage sorghum in Systems I and II. Yields of the forage sorghum in 1973 were 20.4 tons green weight before frost and 8.50 tons dry matter per acre. The 1974 yields of forage sorghum were 40% less, due primarily to a drought in mid-growing season. The tall fescue yielded 1.2 tons of dry matter per acre in 1973 and 1.5 tons dry matter per acre in 1974.

Results of the 1973-74 trial are presented in table 2. The winter of 1974 was milder than usual and cows performed well in every system. No hay was fed to cows in any system except the control cows in System IV, and these were fed less than normal because of the large amount of aftermath grazing available. The sorghum fields became quite muddy on several occasions but no serious problems were encountered. The sod fields remained relatively firm.

Incidence of calf scours was minimal and not confined to any system, with no death loss or serious illness observed. There was no incidence of fescue foot or grass tetany observed in the cows in any system.

Of the 125 cows in the test, 14 were diagnosed open in the fall of 1974. The number of open cows was 3, 7, 1, 3 and 0 for cows in Systems I, II, III, IV and V, respectively. Ten of these cows were "exotic" crosses with a history of breeding problems and were culled from the herd in the fall of 1974. Because of this, caution should be used in making conclusions about re-breeding performance. As previously indicated, cows currently on the test will now remain in the same treatment systems each winter, and will be replaced only in event of death.

All cows gained weight for the first 28 days of the test (Jan. 2 to Jan. 30) with the exception of a few cows calving during this period. There was some forage remaining and some new growth occurring in Systems III and V on April 1, and the winter grazing season for cows in this treatment could have been extended. Calf birth weights were similar, as were the weights per day of age at weaning.

Table 3 presents preliminary results of the 1974-75 test. Cows in the sorghum systems experienced a small average weight loss during the first 28 days from Dec. 16 to Jan. 13, while cows in the other threee systems showed an average gain in weight. There was much more snow fall during the 1974-75 season and cows in all systems received some hay. Because of the lower sorghum forage yields, there were only 88 cow grazing days per acre for Systems I and II, as compared to 148 days for the previous year. Cow grazing days per acre increased for Systems III and V from the previous year. The hay fed to the cows in Systems III and V was harvested from the treatment fields and actually represented only a small amount of the total hay harvested from these two fields. Cows were actually grazed on the System V field at double the rate for the winter test from April 7 to April 17, and at the rate of 1.25 cows per acre from April 18 to May 4.

Spring and summer management of the fescue includes harvesting hay in June and then grazing until Aug. 1, at which time the "stockpiling" begins again. The sorghum fields are not double-cropped, and are no-till planted and plow-planted on alternate years. Systems I and II alternate fields each year. Although forage sorghum may be planted successfully as late as early July with favorable weather conditions, there are indications that if double-cropping is not used, it may be advantageous to plant in May or early June.

On the basis of data to date, all "stockpiling" systems compare favorably with the conventional system of wintering cows. Calves in all treatments have performed well to weaning. No problems have occurred with calving on pasture during the winter months. Labor requirement for cows on the sorghum and fescue treatments has been much less than for cows wintered on the conventional management system.

TABLE 1. CHEMICAL COMPOSITION OF FORAGES[a]

Forage	Crude protein	Ether extract	Crude fiber	Ash	NFE
	%				
Fescue, before frost	10.89	3.06	28.60	6.20	51.24
Fescue, mid-winter	10.45	2.70	31.37	9.32	46.14
Sorghum, before frost	6.02	1.27	36.36	3.02	53.33
Sorghum, mid-winter	6.17	0.86	42.41	2.82	47.59
Hay (System IV)	10.2	2.55	36.51	5.60	45.15

[a]Dry basis.

TABLE 2. PERFORMANCE OF COWS ON DIFFERENT WINTERING SYSTEMS - 1973-74

	System I (Sorghum + liquid supplement)	System II (Sorghum + biuret supplement)	System III (Sorghum & fescue)	System IV (Conventional)	System V (Fescue)
No. of cows	25	25	25	25[a]	25
Weight, 1-2-74, lb.	1004	989	973	973	990
Gain per cow, Jan. 1-30,[b] (28 days), lb.	9	37	92	89	32
Weight of cows, 4-1-74 (final wt.), lb.	909	879	948	937	995
Total feed per cow, lb.	121 (liquid)	18 (biuret mineral)		1800 (hay)	
Cow grazing days per acre	148	148	99		74
No. cows calving before 4-1-74	21	22	19	16	20
No. calves weaned[c]	22	23	20	20	22
Avg. birth weight, lb.	72.5	73.2	75.4	76.4	74.3
Calf wt. per day of age,10-8-74, lb.	1.78	1.77	1.88	1.76	1.81

[a]One cow died accidentally, 3-20-74.
[b]Includes only cows not calving during this period.
[c]Some of cows were open at beginning of test.

TABLE 3. PERFORMANCE OF COWS ON DIFFERENT WINTERING SYSTEMS - 1974-75 (Through 4-7-75)

	System I (Sorghum + liquid supplement)	System II (Sorghum + biuret supplement)	System III (Sorghum & fescue)	System IV (Conventional)	System V (Fescue)
No. of cows	25	25	25	25	25
Weight, 12-16-74, lb.	1074	1102	1106	1140	1119
Gain per cow, 12-16 to 1-13-75 (28 days)	-12	-10	+54	+30	+70
Weight, 4-7-75 (final wt.), lb.	901	870	977	940	1075
Total lb. feed per cow	206 (liquid) 1134 (hay)	22 (biuret-mineral) 1134 (hay)	160 (hay)	2422 (hay)	200 (hay)
Cow grazing days per acre	88	88	124	_[a]	93
No. cows calving before 4-7-75	18	20	20	21	19
Avg. birth weight, lb.	76.7	74.1	80.3	81.5	81.7
Calf wt. per day age to 4-7-75, lb.	3.45	3.53	3.47	3.41	4.21

[a]Some grazing available.

FACTORS AFFECTING BEEF TENDERNESS AS MEASURED BY THE ARMOUR TENDEROMETER

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Tenderness in beef is a major factor on eating quality. Beef tenderness is influenced by many variables including several carcass characteristics, meat preparation and cooking procedures and time. Several methods and procedures have been developed to evaluate meat tenderness either in the chilled carcass or after the meat has been cooked and ready to eat. One of the newer instruments developed for this purpose is the Armour Tenderometer. The objectives of this study were two-fold: 1) to determine the effect of several variables on carcass meat tenderness after approximately 72 hours in the cooler, and 2) to determine the reliability of the Armour tenderometer as an instrument for measuring tenderness in the chilled beef carcass.

Materials and Methods

The carcasses used in this study were from cattle slaughtered in a cooperative cattle breeding project between the Animal Science Department of the Virginia Polytechnic Institute and State University and the Virginia Division of Corrections during 1972 through early 1975 at two locations.

Tenderness and other carcass measurements were taken on 231 cattle at the Southampton Correctional Center and 247 cattle at the Bland Correctional Center. Repeat measurements were obtained on 136 carcasses at Southampton and on 179 carcasses at Bland. At Southampton repeat measurements were taken on only one side but at Bland they were taken on both sides. Variables included in the initial statistical analysis were herds, breeds within herds, sex, slaughter date, age of animal, carcass weight, ribeye area, backfat thickness and marbling score. Since the management practices at the two locations were quite different, with most of the cattle at Bland falling in the good grade and most of the cattle at Southampton falling in the choice grade, the tenderness measurements were different also. Therefore, in later analyses the data from each location were analyzed seperately. Furthermore, age, carcass weight and ribeye area were dropped since they had no significant effect on tenderness measurements in either location.

Simple correlation coefficients were obtained by sex and location, as well as the correlation coefficient over all sexes for each location. To test the reliability of the partial regression coefficients for adjusting tenderness measurements to a common base, as well as to compare the correlation coefficients obtained when certain variables were controlled statistically with the simple correlation coefficients, predicted values were obtained for each of the measurements. This was done by running an analysis of variance and co-variance with replication, breed, sex, slaughter date, backfat thickness and marbling score as sources of variation in the model. Correlation coefficients were then obtained by using the predicted values for each pair of measurements on 315 of the carcasses (136 with two measurements each and 179 with four measurements each).

Results and Discussion

All variables had a highly significant influence on the tenderness measurements at one or both locations except age, carcass weight and ribeye area. Since there was a highly significant herd, or location, effect each herd was analyzed seperately thereafter. Only the major breed groups were included in the second analysis at each location and again it was found that age, carcass weight and ribeye area had no significant effect on tenderness. Consequently, these latter variables were eliminated from later analyses. Other variables that failed to be significant at the .05 level were backfat thickness and marbling score at Bland and sex and backfat thickness at Southampton. Again, however, if both herds were included in the same analysis only age, carcass weight, ribeye area and backfat thickness failed to be significant at the .05 level.

The numbers and means and standard deviations of the carcass traits studied are presented in Table 1.

TABLE 1. NUMBERS, MEANS AND STANDARD DEVIATIONS OF CARCASS DATA BY LOCATION

No. and Traits	Bland	Southampton
Number carcasses	247	231
Age at slaughter	601 ± 92	696 ± 118
Carcass weight	566 ± 98	711 ± 102
Kidney weight	13.5 ± 7.4	26.3 ± 11.9
Ribeye area	12.4 ± 2.0	12.4 ± 1.8
Backfat thickness	.16 ± .09	.60 ± .07
Marbling score	3.5 ± 1.1	5.9 ± 1.8
Carcass grade	9.8 ± 1.7	13.5 ± 3.2
Tenderness score	16.8 ± .12	13.2 ± .20

At Bland cattle averaged 601±92 days of age at slaughter (19.9 months) and produced 566 pound carcasses; whereas, the cattle at Southampton were only three months older (696±118 days or 22.9 months) but produced carcasses averaging 145 pounds heavier and with .44 inches more backfat. The Southampton carcasses scored 2.4 points higher on marbling and were more tender (13.7 *vs* 17.4), but were no larger in ribeye area.

Table 2 presents the tenderness means, standard errors of the means and the correlation coefficients between the repeat tenderness measurements by sex and location.

TABLE 2. NUMBERS, MEANS AND CORRELATION COEFFICIENTS OF TENDERNESS MEASUREMENTS BY SEX AND LOCATION

Location	Sex	No. of Carcasses	No. of Measurements	Mean & Std. Errors Left Side	Right Side	Correlation Coefficients
Bland	Bulls	58	232	17.59±.10	17.80±.09	.68±.07
	Steers	80	320	16.26±.12	16.36±.12	.72±.05
	Heifers	41	164	16.81±.10	16.73±.11	.67±.08
	Combined	179	716	16.82±.12	16.91±.12	.70±.19
South-ampton	Steers	32	64	13.53±.17	13.73±.18	.78±.06
	Heifers	104	208	13.04±.19	13.22±.20	.88±.09
	Combined	136	272	13.15±.20	13.34±.20	.80±.19

At Bland, where there was a significant sex difference, steers were most tender, heifers intermediate and bulls the least tender. Among the breed groups (Table 3), Simmental crosses were most tender with straightbred Herefords intermediate, followed by Angus and the Charolais crosses were the least tender. Slaughter date had a highly significant effect on the tenderness score obtained, fluctuating back and forth, probably depending on the breed composition for the particular slaughter date, the length of time of the carcass in the cooler and the individual variation of the person recording the tenderness measurements.

At Southampton, where the cattle were much fatter and three months older and only steers and heifers were slaughtered, there was no significant difference due to sex. There was a highly significant breed effect (Table 3), with the Holstein x Angus crosses being the most tender, straightbred Angus intermediate, and the Charolais x Angus crosses the least tender. Slaughter date had a highly significant effect, probably due to the same reasons pointed out for the Bland Cattle.

TABLE 3. TENDERNESS MEASUREMENTS BY BREED AND LOCATION

Bland Breed	Tenderness	Southampton Breed	Tenderness
Angus	17.39	Angus	13.31
Char x Her	17.73	Char x Ang	14.35
Sim x Her	15.81	Hol x Ang	12.50
Hereford	16.80		

Some other interesting relationships observed and shown in table 4 are as follows: 1) although the correlations of age, live weight, carcass weight and ribeye area with tenderness were low they increased in relationship as the animals became fatter; 2) the relationship between marbling and tenderness was also rather low but apparently changed directions with degree of fatness. At the low levels of marbling (at Bland) the relationship was positive and with the high levels of marbling (at Southampton) the relationship was negative; 3) the relationship between tenderness and carcass grade was low (.34) but positive and significant in the less fat carcasses at Bland but extremely low and non-significant in the fat carcasses at Southampton; 4) there was also a significant relationship between tenderness and yield in beef carcasses with the relationship being positive in the leaner carcasses and negative in the fatter carcasses.

TABLE 4. CORRELATION BETWEEN VARIOUS CARCASS TRAITS AND TENDERNESS BY LOCATION

Trait	Bland	Southampton
Age at slaughter	-.07 ± .57	-.18 ± .05
Live animal wt.	-.23 ± .01	0.27 ± .004
Carcass weight	-.17 ± .06	-.35 ± .0004
Kidney knob wt.	0.24 ± .009	0.38 ± .0001
Ribeye area	-.25 ± .006	0.34 ± .0005
Backfat thickness	0.38 ± .0001	0.35 ± .0003
Marbling score	0.34 ± .0003	-.55 ± .0001
Carcass grade	0.34 ± .0004	0.11 ± .23
Yield grade	0.37 ± .0001	-.45 ± .0001

The correlation coefficients between repeat measurements of tenderness shown in table 2 are estimates of the repeatability of the Armour Tenderometer. The repeatability of this instrument appears to be considerably better for the more fat and more tender carcasses. The correlation coefficients shown are unadjusted for any of the sources of variation in tenderness measurements discussed above.

Predicted values for each of the repeat tenderness measurements were calculated by using a statistical model including the variables of breed, sex, slaughter date, backfat thickness and marbling score. Then a correlation coefficient of .9999 was obtained between the many pairs of repeat measurements, indicating that the model was highly effective in removing the sources of variation. We are now working on a procedure to remove the significant sources of variation in individual tenderness measurements that will permit a more accurate estimate of the true measure of tenderness.

Summary

Repeat tenderness measurements were obtained on 315 bull, steer and heifer carcasses at two locations to determine the repeatability of scores by the Armour tenderometer. These values were .68±.07, .72±.05 and .67±.08 for bulls, steers and heifers, respectively, at Bland and .78±.06 and .88±.09 for steers and heifers at Southampton. With all sexes combined the correlation coefficients were .70±.19 and .80±.19 at Bland and Southampton, respectively. The Southampton cattle were three months older and much fatter than the Bland cattle.

Factors significantly influencing the tenderness scores were location, age, sex (Bland only), breed, slaughter date, and marbling.

* * * * *

The authors express their sincere appreciation to personnel of the Virginia Division of Corrections and especially to Raymond Wilson of Bland and Eugene Grizzard of Southampton for taking the tenderness measurements.

THE RELATIONSHIP OF VISUAL SCORES, BODY MEASUREMENTS, AND FAT THICKNESS WITH PERFORMANCE AND COMPOSITION OF BULLS ON 140-DAY FEED TEST

G. L. Minish and C. W. Tankersley

Introduction

Prior to the past decade, beef cattle selection has been done primarily by visual appraisal. Current trends lead us to believe that present type and classification scores are poorly related to maximum production efficiency. Feeder grades appear to be emphasizing poor gaining inefficient cattle that are early maturing and carry an excess amount of fat.

Body measurements have recently gained popularity for improving selection processes for beef cattle. Skeletal length and skeletal heights have been shown to be positively and highly correlated with growth. Previous studies have shown that evaluation on the basis of measurement has the advantages of: (1) being independent of human judgment, and (2) remaining standard over long periods of time in contrasts to subjective conformation and type standards which change from time to time.

Current research has shown that scrotal circumference and testical tenacity is positively correlated with semen production. Limited research suggests that average daily gain is positively correlated with scrotal circumference, and neagatively correlated with tonometer measurements. More conclusive information in this area is needed to substantiate this early work.

Previous work in correlating visual scores of frame and muscling has indicated that higher frame and muscling scores were positively correlated with average daily gain on test, and pounds of edible beef produced per day of age.

Against this background, this project was designed to relate body measurements, composition estimates and testical values with the performance data of bulls on 140-day feed test.

Procedure

Research was conducted on bulls from the V.P.I. & S.U. teaching and research herds. Twenty-four bull calves of various breeds ranging in age from 180 to 260 days were weaned and allotted as evenly as possible for weight, breed, and age to the two following treatments: Treatment I consisted of a full-feed of corn silage, 1.0 lb. of cracked corn per 100 lbs. of body weight, and 2.0 lbs. of supplement per head per day consisting of 1.0 lb. of 44% soybean oil meal and 1.0 lb. of cracked corn and 30,000 I.U.'s of Vitamin A; Treatment II received a full-feed of corn silage, 1.0 lb. of cracked corn per 100 lbs. of body weight, and 2.0 lbs. of supplement consisting of 44% of soybean oil meal and 30,000 I.U.'s of Vitamin A. Both treatments were provided a free choice salt-mineral mix of one part trace mineralized salt, one part ground limestone and one part de-flourinated rock phosphate.

The length of the official feed test was 140 days. Bulls were weighed and measured every 28 days while on test, and average daily gain, height at the withers, height at rump, body length from the point of shoulder to the pin bone, and length of cannon data were collected.

At the beginning and end of the 140-day test period, the following data were collected: Bulls were visually scored for frame on a 1 to 7 basis (1 = smallest, and 7 = largest), and for cutability according to the U.S. D.A. yield grade standards; scrotal circumference was measured and tenacity of the testes was determined with a tonometer, and fat thickness was estimated ultrasonically.

The data was statistically analyzed using multiple regression to study the relationship of gain on test to body measurements, visual appraisal scores, fat thicknesses, scrotal circumferences and tonometer readings. In addition, product-moment correlations among the variables were computed.

Results and Discussion

Data for each treatment group of bulls were pooled and differences between treatments were statistically removed. Performance data, fat thickness, and yield grade were correlated with body length, withers height, rump height, cannon length, frame score, scrotal circumference, testicular tonometer readings, and each other.

The performance data correlated included adjusted 205-day weight, average daily gain on the entire test, and weight per day of age at the end of test. Fat thickness and yield grade at the beginning of test and again at the end of test were correlated with each parameter.

Table 1 gives the correlations of the performance data, fat thickness, and yield grades with the measurements taken at the beginning of the test. Table 2 gives the correlations of the performance data, fat thickness, and yield grades with measurements taken at the end of the official test.

The data from Tables 1 and 2 indicate that cannon length is the most significant body measurement of those taken at the beginning of test to correlate with performance data of the bulls. Body length, withers height, and rump height were shown to have smaller correlation coefficients with performance data. However, the body length, withers height, and rump height taken at the end of test was quite significant and highly correlated with the performance data of the bulls. These findings substantiate earlier findings that cattle reach their mature cannon length at earlier ages than their mature body length, withers height, and rump height.

It should be noted that body length, withers height, and rump height measurements taken at the beginning of the test were not significantly correlated with average daily gain on test. However, these same measurements, taken at the end of test, correlated with average daily gain, were quite significant. This latter finding indicates that longer and taller bulls have greater gains on test and have higher weights per day of age than do shorter and more compact bulls.

Yield grade was negatively correlated ($P<.01$) with each body measurement and frame score, and was positively correlated ($P<.01$) with fat thickness. This suggests that the taller, stretchier bulls were trimmer, had less fat, and possessed more desirable yield grades than did shorter, more compact bulls which tended to have more backfat and poorer yield grades.

Average daily gain was significantly and negatively correlated ($P<.05$) with tonometer readings. Weight per day of age was negatively correlated with tonometer readings and scrotal circumference measurements, although the correlations were not significant or high. Frame scores were significant ($P<.05$) and quite highly positively correlated with body measurements and highly negatively correlated with fat thickness and yield grade. Yield grade scores were significantly ($P<.01$) negatively correlated with body measurements of size.

In view of these findings, it seems that the visual appraisal parameters, frame and yield grade scores, are accurate in assessing size and composition of beef bulls. Visual selection for large frame and top yield grading beef bulls would tend to emphasize less backfat, and greater performance and composition of young beef bulls on test.

TABLE 1. CORRELATION COEFFICIENTS BETWEEN AND WITHIN BODY MEASUREMENTS, VISUAL SCORES, AND FAT THICKNESS TAKEN AT THE BEGINNING OF TEST AND PERFORMANCE OF BULLS ON 140-DAY FEED TEST

	205-Day Wt., lbs.	Length Inches		Withers Ht., in.	Rump Ht., in.	Frame Score	Yield Grade	Fat, in.
		Body	Cannon					
205-day[a] wt., lbs.	---	.34	.64*	.45**	.45**	.48**	-.44**	-.04
ADG, lbs.[b]	.12	.25	.47**	.38	.36	.39	-.12	-.27
WDA, lbs.[c]	.61*	.37	.67*	.53*	.51**	.55*	-.30	-.22
Fat-start[d] of test, in.	-.04	-.18	-.37	-.35	-.42**	-.54*	.39	---
Fat-end of[d] test, in.	-.20	-.14	-.36	-.35	-.39	-.49**	.41	.67*
Yield grade[e] start of test	-.44**	-.67*	-.68*	-.74*	-.81*	-.78*	---	.39
Yield grade[e] end of test	-.39	-.63*	-.68*	-.77*	-.81*	-.82*	.78*	.58*
Frame score start of test	.48**	.76*	.85*	.94*	.92*	---	-.78*	-.54*
Frame score end of test	.46**	.70*	.85*	.87*	.85*	.92*	-.72*	-.57*

*Significantly correlated (P<.01).
**Significantly correlated (P<.05).
[a]205-day weight adjusted for age of dam.
[b]Average daily gain calculated for 140 days on test.
[c]Weight per day of age calculated at the end of 140-day test period.
[d]Fat thickness estimated at the 12th rib with the son-o-ray.
[e]Yield grade = visual estimation of percent boneless, trimmed round, rib, loin, and chuck.

TABLE 2. CORRELATION COEFFICIENTS BETWEEN AND WITHIN BODY MEASUREMENTS, VISUAL SCORES, AND FAT THICKNESS TAKEN AT THE END OF TEST AND PERFORMANCE OF BULLS ON 140-DAY FEED TEST

	205-Day Wt., lbs.	ADG, lbs.	WDA, lbs.	Length Inches Body	Length Inches Cannon	Withers Ht., in.	Rump Ht., in.	Frame Score	Yield Grade	Fat, in.	Scrot. Circum. in.	Tena-city[f]
205-day[a] wt., lbs.	---	.12	.61*	.33	.46**	.47**	.52**	.46**	-.39	-.20	-.06	-.09
ADG, lbs.[b]	.12	---	.81*	.72*	.53*	.48**	.45**	.40	-.28	.06	.11	-.45**
WDA, lbs.[c]	.61*	.81*	---	.77*	.62*	.59*	.60*	.60*	-.41	-.09	-.06	-.36
Fat-start[d] of test, in.	-.04	-.27	-.22	-.32	-.52**	-.36	-.53*	-.57*	.58*	.67**	-.11	.02
Fat-end of[d] test, in.	-.20	.06	-.09	-.25	-.49**	-.35	-.50**	-.55*	.52**	---	.21	.08
Yield grade[e] start of test	.44**	-.12	-.30	-.57*	-.72*	-.72*	-.78*	-.72*	.78*	.41	-.06	-.13
Yield grade[e] end of test	-.39	-.28	-.41	-.57*	-.72*	-.66*	-.76*	-.78*	---	.52**	.02	.05
Frame score start of test	.48**	.39	.55*	.72*	.84*	.89*	.94*	.92*	-.82*	-.49**	.25	-.02
Frame score end of test	.40	.40	.60*	.74*	.84*	.85*	.90*	---	-.78*	-.55*	.04	-.13

*Significantly correlated (P<.01).
**Significantly correlated (P<.05).
[a]205-day weight adjusted for age of dam.
[b]Average daily gain calculated for 140 days on test.
[c]Weight per day of age calculated at the end of 140-day test period.
[d]Fat thickness estimated at the 12th rib with the son-o-ray.
[e]Yield grade = visual estimation of percent boneless, trimmed round, rib, loin, and chuck.
[f]Tenacity is a measure of deflection on a scale of 0-2 divided into tenths.

PERFORMANCE OF ANGUS x HOLSTEIN AND ANGUS COWS AND THEIR CALVES ON TWO WINTER FEEDING LEVELS

T. N. Meacham, J. P. Fontenot and R. C. Carter

Introduction

While the growth and beef producing capabilities of the various types of crossbred beef cows have been recognized, the reproductive performance of these various crosses, particularly those involving the large dairy or continental breeds, is not well defined. One question which has not been answered is whether the larger, heavier milking crossbred cow can function on the marginal feed intakes frequently encountered during the winter feeding periods as well as the straightbred beef cow.

Procedure

To study this question, two groups of yearling heifers, 65 Angus x Holstein and 65 straight Angus heifers, were purchased in 1974. The heifers were wintered at the Catawba Research Unit. They will be bred to Angus bulls in the spring of 1975 and the reproductive performance evaluated. The pregnant heifers will be divided in the fall, and one-half of each breed group wintered at 100% of the N.R.C. energy requirement level, and the other half will be fed at 80% of the N.R.C. level. Corn silage and mixed hay will be fed. Calving ease, calf birth and weaning weights, intervals from calving to first estrus and conception, and conception rates will be measured.

Calves from the females will be fed out on various high roughage rations. The male calves will be fed as bulls.

The cows will be bred artificially to either Polled Hereford or Charolais bulls for their second and subsequent calf crops. The effects of the sires on calving and growth and feedlot performance will be evaluated.

Results

No experimental results are available at this time.

IMPROVING GROWTH RATE IN HAMPSHIRE SHEEP

H. D. Hupp, R. C. Carter, J. S. Copenhaver, W. H. McClure
F. S. McClaugherty

The mutton or Down breeds of sheep, such as the Hampshire or Suffolk, exist primarily to furnish rams to sire market lambs from ewes of a variety of breeds and crosses. Growth rate of the lamb from birth to market or weaning weight is the most important economic characteristic to be selected for in these "ram" breeds. However, heritability of pre-weaning growth rate in these breeds has been found to be quite low, various estimates ranging from near zero to 10-15%. Results from progeny testing of more than 200 Hampshire rams, over a period of nearly two decades, at the Virginia Station, has shown near zero correlation between the pre-weaning growth rate of a ram and the growth of the lambs that he sires.

With such low heritability, or such low predictive value of a ram lamb's own growth rate as an indication of his breeding value, direct selection on individual performance to weaning is not particularly encouraging. Selection on the basis of progeny testing of rams should be more effective, although it is more expensive and time consuming.

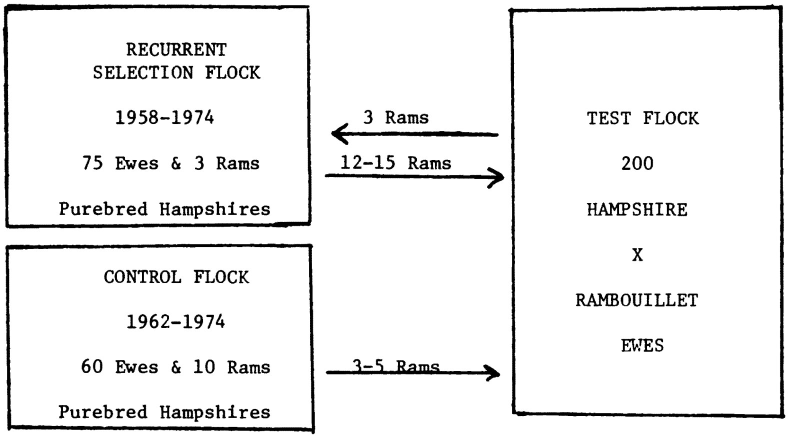
Experimental Procedure

An experiment to test the effectiveness of progeny testing as a basis of selection for the improvement in lamb growth rate was started at the Virginia Station in 1956. Samples of purebred Hampshires, both rams and ewes, were obtained from 14 flocks widely distributed over the United States. Two closed flocks were established from this foundation.

In one flock of 3 rams and about 75 ewes, selection is practiced on the basis of progeny testing of rams and selection of those with the fastest-gaining lambs. This procedure is known as recurrent selection and the flock designated as Recurrent Selection (RS) flock. Another group of 10 rams and 50-60 ewes is maintained without selection as a Genetic Control (GC) flock from which to measure progress made by recurrent selection in the RS flock.

Each year 15 ram lambs from the RS flock are progeny tested by mating each to 10 Hampshire x Rambouillet ewes in a test flock. The 3 rams, of the 15 tested, with the fastest-gaining lambs from birth to market weights of 95-100 pounds are selected to go back onto the RS flock, replacing the 3 rams used the previous year. At the same time 5 rams from the GC flock are also progeny tested by breeding them to 10 of the Hampshire x Rambouillet ewes each. Comparison of the growth rate of the lambs sired by the RS and GC rams provides a measure of the progress made by the selection practiced. The progeny testing and mating scheme is shown in the following diagram.

BREEDING SCHEME



Results And Discussion

Twenty ram lambs were progeny tested in 1973-74 by breeding each to some 12 ewes in the test flock at Steeles Tavern. These consisted of 14 ram lambs selected at random from the RS flock, 4 from the GC flock and 2 from the outbred flock of the VPI Animal Science Department at Blacksburg. The ewes in the test flock were Suffolk crossbreds and were either 3 or 4 years old. All lambs were weaned at about 60 days of age and finished to market weight of 90 to 110 pounds in total confinement on slatted floored pens. The lambs were self-fed a complete pelleted ration.

Average daily gains (from birth to market weight) of groups of lambs sired by the 20 rams are presented in table 1, ranked from the highest to lowest. The first 6 progeny groups were sired by the RS rams. The progenies of the 4 GC rams ranked 9th, 13th, 17th and 20th of the 20 rams tested. The 2 rams from the college outbred flock ranked 7th and 19th.

Table 2 presents the average of the progeny daily gains for the RS and GC lambs for each of the last 7 years. With two exceptions, the RS rams were distinctly superior to the GC rams with respect to progeny growth rates, especially in the last year. Since the project was terminated, no rams were selected for the next breeding season, hence no selection differential for 1974. The same information is shown graphically in figure 1. The upper line shows the difference between the average growth rate of all RS and GC rams progenys. The horizontal base line represents the means of the lambs by the GC rams.

The results are encouraging. There is a positive trend to increase average daily gain from birth to market weight. The positive regression coefficient of .01 emplies the average progress in increasing ADG each year was .01 lbs./day/year. This suggests that progress has been made in improving breeding value of the flock for transmitting rapid growth to their crossbred progeny.

TABLE I. RAM PROGENY AVERAGE DAILY GAINS FROM BIRTH TO MARKET WEIGHT (90-110 lb) - 1973-74

Rank	Ram No.	Progeny ADG[ab]	Flock or Origin
1	W-229	.878	RS (Recurrent Selection)
2	W-227	.817	RS
3	W-242	.765	RS
4	W-222	.761	RS
5	W-218	.722	RS
6	W-208	.700	RS
7	W-108	.695	OB (College Outbred)
8	W-228	.667	RS
9	W-602	.654	GC (Genetic Control)
10	W-241	.646	RS
11	W-230	.645	RS
12	W-214	.628	RS
13	W-633	.625	GC
14	W-238	.623	RS
15	W-220	.620	RS
16	W-245	.620	RS
17	W-618	.597	GC
18	W-239	.558	RS
19	W-105	.538	OB
20	W-606	.533	GC

[a]Means adjusted for number of progeny produced, sex, type of birth and rearing, and age of ewe.

[b]Recurrent Selection Average .686 lb/day
Genetic Control Average .603 lb/day
College Outbred Average .572 lb/day

TABLE 2. PROGENY TEST ADG MEANS FOR RECURRENT SELECTION AND GENETIC CONTROL FLOCKS[ab]

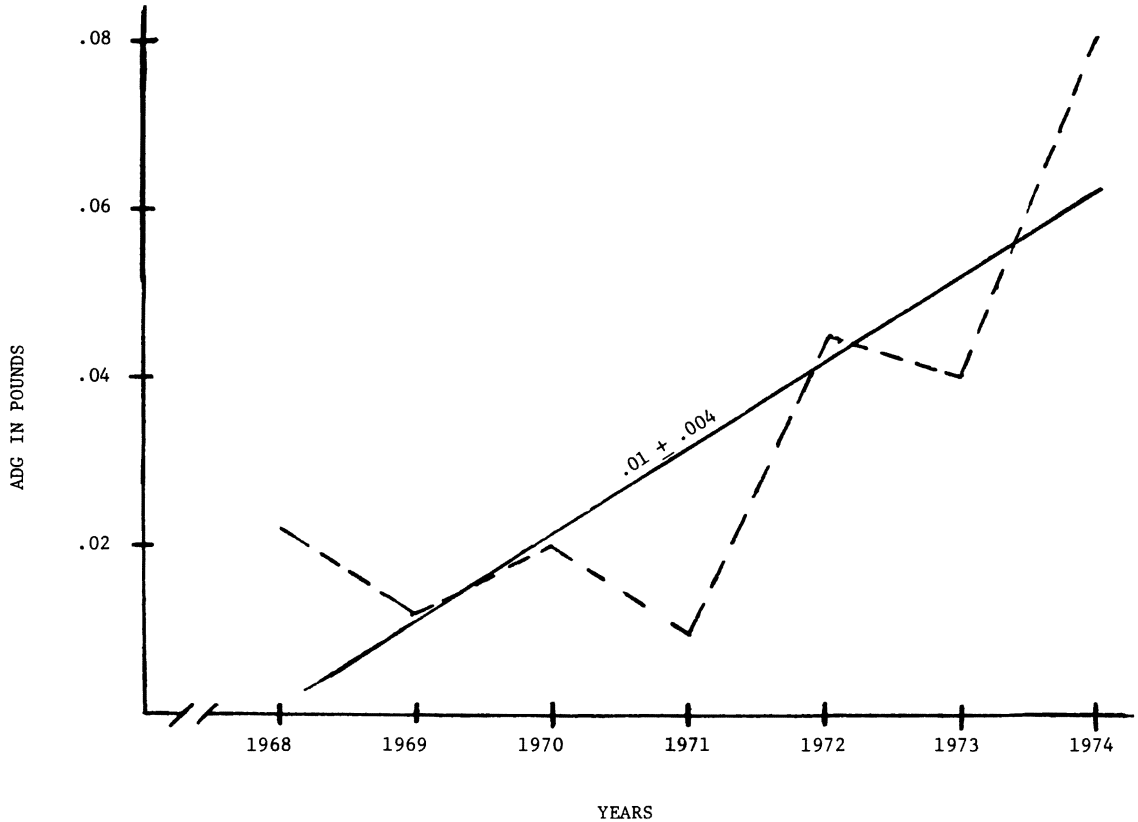
	Recurrent Selection		Genetic Control
Year	Mean ± S.E.	S.D.[c]	Mean ± S.E.
1968	.620 ± .030	.042	.597 ± .022
1969	.618 ± .037	.056	.617 ± .033
1970	.646 ± .030	.036	.626 ± .014
1971	.610 ± .045	.017	.604 ± .040
1972	.436 ± .052	.058	.391 ± .050
1973	.518 ± .027	.030	.477 ± .014
1974	.686 ± .081		.603 ± .052
Mean	.603 ± .112		.574 ± .089

[a]Weight in pounds.

[b]Means adjusted for number of progeny produced, sex and type of birth-rearing.

[c]Selection Differential.

FIGURE I. ADG DIFFERENCES BETWEEN REUCRRENT SELECTION AND GENETIC CONTROL FLOCKS



HETEROSIS FROM CROSSES AMONG BRITISH BREEDS OF BEEF CATTLE

J. A. Gaines, R. C. Carter and W. H. McClure

The objective of the phase of the experiment to be reported here is to compare straightbred calves with three-breed cross calves out of two-breed cross dams. This is a continuation of previously reported results from crossing the Angus, Hereford and Shorthorn breeds, and it is preliminary to results comparing straight-breeding with rotational crossbreeding.

In 1960, the cow herd originally consisted of sixty straightbreds (Angus, Hereford and Shorthorn) and sixty crossbreds (reciprocal two-breed crosses) among the three breeds. It has dwindled to 33 straightbreds and 43 crossbreds. The first five calf crops were used to compare straightbred and crossbred cows, and the results have been reported. The sixth through twelfth calf crops are included in this report. Results through weaning are complete, as follows: 312 straightbred matings weaned 261 calves (83.7%); 347 crossbred matings weaned 324 calves (93.4%). There are large differences in birth weight, weaning weight, slaughter weight, and carcass weight, all in favor of the crossbreds. Differences in quality, as measured by feeder grade, slaughter grade, and carcass grade are negligible. The increase in total yield at weaning is of the order of 24%. The project has been extended for one year, so one more calf crop will be weaned from these cows, after which a publication will be prepared comparing lifetime production of straightbred versus crossbred cows.

INBREEDING VS SELECTION FOR IMPROVEMENT OF GROWTH IN BEEF CATTLE

R. C. Carter, J. S. Copenhaver and Will T. Butts, Jr.[1]

A long term breeding experiment designed to compare inbreeding and subsequent crossing of inbred lines, with selection for growth rate , or body conformation, was conducted at the Beef Cattle Research Station, Front Royal from 1950 to 1973. Four inbred lines and two single trait selection lines were developed in each of the Angus, Hereford and Shorthorn breeds. In one of the selection lines selection was based solely on growth rate from birth to yearling age; in the other, the sole criterion was type or body conformation.

Tests to compare the breeding values of bulls of the four inbred lines and the growth and type lines in the Shorthorn breed have been going on at Blacksburg for several years. Bulls produced in the Front Royal Shorthorn lines are then bred to an unrelated herd of high grade Shorthorn cows. The breeding value of the bulls of the various lines is measured by the performance of the calves they sire.

This test is now in Phase II in which bulls of each inbred line are mated to daughters of each of the other lines but not to daughters of their own line. However, bulls of the growth and type selection lines are mated to daughters of bulls of their own line. This gives a comparison of rotational crossing of inbred lines, which should give some heterosis, with continuous selection for a single trait.

The table below shows the average weaning weights of calves of the 1974 calf crop. Steers and Heifers are shown seperately.

Line of	Weaning Weights	
Sire	Steers	Heifers
Inbred 1	601 lb.	529 lb.
Inbred 2	577 lb.	485 lb.
Inbred 4	560 lb.	514 lb.
Inbred 5	535 lb.	512 lb.
Type Selection	496 lb.	450 lb.
Growth Selection	636 lb.	569 lb.

It is clear that the growth selection line bulls sired the heaviest calves but at least one inbred line (1) was very satisfactory. The average of all inbred lines is well below that of the growth line. By far the poorest were those sired by bulls of the type line.

[1]Leader in Beef Cattle breeding research, Southern Region, U.S.D.A., A.R.S., Knoxville, Tennessee.

"LITTERS OF LAMBS"

Performance of Finn Cross Ewes

R. C. Carter, J. S. Copenhaver and F. S. McClaugherty

Research is in progress to evaluate the value of the Finnish Landrace breed of sheep in crosses with conventional breeds of the Blacksburg and Glade Spring Stations.

At Blacksburg we have ewes with 1/2 and 1/4 Finn blood, the other 1/2 or 3/4 being Rambouillet. These ewes are under an intensive management system with the lambs weaned at about five weeks of age and the ewe rebred in an attempt to raise a lamb crop at about eight month intervals.

The Finn Cross flock at the Southwest Virginia Station, Glade Spring, also consists of 1/2 and 1/4 Finn blood but the base breed is Dorset rather than Rambouillet as at Blacksburg. At Glade Spring conventional management is followed with the ewes lambing over a year and rearing their lambs to marketing or normal weaning age largely on permanent pasture.

There are two ages of ewes at both places, yearlings and two year olds. At Blacksburg the ewes are first exposed to rams in March and April when they are about 12 months of age. Those settling to the March-April service and lambing in September are rebred in November. Those not lambing in September are bred in September for January-February lambing and rebred in March and April. This has the ewes lambing in September, January-February and March-April.

The cumulative production for the two ages of ewes under this system is shown in table 1 below. The striking feature of this table is the high level of prolificacy of the half Finn ewes. The average number of lambs raised to weaning age (5-6 weeks) is 2.01%. This is quite high for such young ewes and includes the out of season breeding and lambing periods. The corresponding figure for the quarter Finns is 1.54%.

TABLE 1. CUMULATIVE EWE PERFORMANCE, CROSSBRED EWES, BLACKSBURG, 1973-75

Two Year Old Ewes	No. Ewes	No. Lambings	Lambs Weaned	Lambs Lost
Suff. x Ramb.	19	19	34	2
1/2 Finn	30	74	148	12
1/4 Finn	42	66	102	2
Year Old Ewes	32	44	89	5
1/2 Finn	48	59	90	2

Glade Spring Project

As was mentioned above at the Glade Spring Station the Finn Cross ewes are on a Dorset base and are either 1/2 Finn-1/2 Dorset or 1/2 Finn-3/4 Dorset. A few purebred Dorsets are kept for control. Results from the 1975 spring lamb crop are shown by the two ages of ewes in the table below.

TABLE 2. EWE PERFORMANCE, GLADE SPRING, 1975

Two Year Old Ewes	1/2 Finn	1/4 Finn	Dorset
No. ewes	24	17	6
No. lambing	23	17	6
Lambs born	52	36	10
Lambs raised	42	33	8
Lambs raised/ ewe exposed	1.75%	1.94%	1.33%
Yearling Ewes			
No. ewes	26	20	9
No. lambing	26	19	8
Lambs born	51	31	11
Lambs raised	41	27	8
Lambs raised/ ewe exposed	1.96%	1.55%	1.22%

The striking characteristic of the Finn Cross ewes, particularly the half breds, is their high level of prolificacy. Even at the young ages and lambing out of season most ewes have twins with a substantial number of triplets and occasionally quadruplets. The Finn ewes lamb easily, are good mothers and good milkers. The lambs are hardy and lamb losses are low. Introduction of some Finn breeding into a flock can be depended upon to increase the lambing percentage.

The most spectacular performance with 1/2 Finn ewes is a group of 8 four year ewes. These eight ewes were bred first as ewe lambs and have been bred a total of four lamb crops. They have produced 89 lambs in a three year period of which 82 were raised to weaning.

FERTILITY AND CALF PERFORMANCE TO WEANING AT SOUTHAMPTON FARM

T. J. Marlowe, E. M. Grizzard[1] and W. E. Burgess[2]

This cooperative research was initiated in late 1968 between the Animal Science Department of VPI & SU and the Southampton Correctional Farm, as an outgrowth of an earlier cooperative project related to progeny testing of bulls from the Beef Cattle Research Center at Front Royal.

The specific objectives of this cooperative research were: 1) to evaluate three sire breeds (Angus, Charolais and Holstein) when bred to Angus cows, 2) to evaluate the resulting female offspring as cow breeds when bred to bulls of still another breed, and 3) to determine the best combination of breeds and mating schemes for maximizing beef production.

Cattle Management and Mating Schemes

In December, 1968, 90 Angus cows were allotted at random, within age groups, to three breeding groups. Two bulls each of the Angus, Charolais and Holstein breeds were randomly alloted by breeds to the cow groups, except that the cow group bred to Charolais bulls was subdivided with a random half of the cows going to each bull. In December, 1969 two different bulls of the three breeds were again randomized to the same cow groups with the restriction that no sire breed would be bred to the same cow group as the previous year. This time the Charolais bulls were not seperated. The same procedure was again followed in December, 1970 with the restriction that each bull breed be used only once on each group of cows within the three year period. In December, 1971 all of the cows were again allotted at random, within age groups, to three new breeding groups and the same procedure of allotting bulls to the cow groups was followed as described for the first three years.

Over the six breeding seasons there were a total of 12 Angus, 12 Charolais, and 12 Holstein bulls used. An effort was made to obtain as good a representative of each of the bull breeds as possible within the means available. Each year the breeding season lasted for 75 days from about December 15 to March 1.

Cows were wintered on corn, peanut, and soybean stubble by gleaning the fields during the breeding season. Field gleanings were supplemented with hay and sorgum silage (1 lb. hay to 2 lb. silage) as needed to keep the cows in reasonable condition. When the field gleanings got short they were given 2 lb. of ground corn and cob meal (supplemented with 200 lb. SBOM per ton) per head daily. They were turned on permanent pasture, consisting mainly of fescue, around April 1 of each year.

[1,2]Farm Director and Herdsman, respectively, at the Southampton Correctional Farm.

Calves were weaned during May of each year and the cows left on permanent fescue pasture until going back on field stubble in late October. All calves were weighed and scored for conformation and condition at weaning. Post-weaning management and performance of these calves will be presented in another paper.

In addition to the cattle described above, a small straightbred Charolais herd was maintained as a seperate breeding unit with the exception that one of the Charolais bulls used in this herd was also used as one of the Charolais bulls on the Angus cows. The breeding season was different for the Charolais herd, starting about April 1 and running for 75 days. Although the breeding season was different, the fertility and calf performance of these cattle are shown along with the others.

Results and Discussion

The data are presented in tables for convenience in making comparisons. They include fertility, cow and calf losses, calves weaned, birth weight, and weaning weight , grade and condition score.

Fertility and Calving Percentage

The fertility and calving percentage by breed of sire when bred to Angus cows for each of the five years are shown in table 1. Fertility and calving percentages are expressed as the ratio of calves weaned to cows exposed to bulls. Also shown is the number of open cows, calf losses, and cow death. Over the six breeding seasons 180 cows were exposed to Angus bulls , 184 cows to Charolais bulls and 174 cows to Holstein bulls. The corresponding calving percentages were 83.3 for Angus sires, 81.5 for Charolais sires bred to Angus cows, and 83.3 percent for Holstein sires. Also, there were 80 breeding exposures of Charolais cows to Charolais bulls, resulting in a calving percentage of 82.7%. The number of open cows was significantly higher in the Angus and Charolais sire groups when mated to Angus cows. However, the large number of open Angus cows in the Charolais sire group was accounted for largely by one sterile bull during the first year , accounting for 12 of the 21 open cows during the six breeding seasons.

Calf death losses were greatest for the large sire breeds, particularly among the Holstein-sired calves. Cow death losses were significantly higher in the groups bred to Charolais bulls. The higher fertility rates among the cows bred to bulls of a different breed were offset by greater calf losses, primarily at birth, so that the calving percentages weaned were not significantly different. If, however, the 12 Angus cows exposed to the sterile Charolais bull were not included the percent calves weaned would be significantly higher for the Charolais sires (87.2 vs 83.3).

TABLE 1. FERTILITY AND CALVES WEANED: SIRE BREED EVALUATION AT SOUTHAMPTON FARM

Sire Breed	Year	Cows Exposed	Cows Open	Calf Losses	Cow Deaths	Calves Weaned Number	Calves Weaned Percent
Angus[1]	1970	30	6	2	0	24	80.0
	1971	36	9	4	1	23	63.9
	1972	37	1	1	0	35	94.6
	1973	31	4	0	0	27	87.1
	1974	24	0	0	0	24	100.0
	1975	22	3	1	1	17	77.3
	Totals	180	23	8	2	150	83.3
Charolais[2]	1970	6	1	0	0	5	83.3
	1971	10	1	0	0	9	90.0
	1972	13	1	1	0	11	84.6
	1973	13	0	0	0	13	100.0
	1974	18	3	1	1	13	72.2
	1975	20	3	2	0	15	75.0
	Totals	80	9	4	1	66	82.7
Charolais[1]	1970	30	12[3]	1	1	17	56.7
	1971	43	2	1	0	40	93.0
	1972	37	2	6	3	27	73.0
	1973	30	3	0	0	27	90.0
	1974	21	1	1	1	19	90.5
	1975	23	1	2	1	20	86.9
	Totals	184	21	11	6	150	81.5[4]
Holstein[1]	1970	30	1	0	0	29	96.6
	1971	30	1	4	0	25	83.8
	1972	37	5	3	0	29	78.4
	1973	35	4	5	0	26	74.3
	1974[5]	20	2	2	1	16	80.0
	1975	22	1	1	0	20	90.9
	Totals	174	14	15	1	145	83.3

[1]Bred to Angus cows.

[2]Bred to Charolais cows.

[3]Exposed to sterile bull.

[4]If cows with sterile bull are eliminated overall % calves weaned becomes 87.2%.

[5]One cow prolapsed.

If one looks at the fertility and calving percentages by kind of calf, as shown in table 2, again it is obvious that fertility is higher in the crossbred matings but this advantage is lost as a result of the higher death losses at birth among the larger crossbred calves so that the percent of calves weaned is not different (82.4% *vs* 83.1%). Again, if the 12 cows exposed to the sterile Charolais bull were eliminated the percent calves weaned would be 85.3 for the crossbreds and 83.1 for the straightbreds.

TABLE 2. FERTILITY AND CALVES WEANED: STRAIGHTBRED *VS* CROSSBRED CALVES OUT OF STRAIGHTBRED COWS, 1970-1975, AT SOUTHAMPTON FARM

Kind of Calf	Cows Exposed	Cows Open	Calf Losses	Cow Deaths	Calves Weaned Number	Calves Weaned Percent
			Straightbred Calves			
Angus	180	23	8	2	150	83.3
Charolais	80	9	4	1	66	82.5
Combined	260	32	12	3	216	83.1
			Crossbred Calves			
Char x Ang	184	21	11	6	150	81.5[1]
Hol x Ang	174	14	15	1	145	83.3
Combined	358	35	26	7	295	82.4

[1]If 12 cows exposed to sterile bull were eliminated calving percentage would be 87.2% and all crossbreds 85.3%.

Birth Weights

Birth weights are shown in table 3 by breed of sire and dam. Straightbred Charolais calves were about 22 lb. heavier (34.4%) at birth than straightbred Angus calves. Crossbred calves were intermediate in birth weight, with the Holstein crosses being only slightly less than the Charolais crosses. There were no serious calving difficulties in any group with only a few calves having to be pulled. As pointed out above, however, there were more dead calves at birth among the crossbreds than among the straightbreds.

Male calves were heavier at birth than female calves for all breed groups except the straightbred Charolais calves where the females averaged 3.6 lb. heavier than the males. Among the other groups, males averaged 5.6 lb. heavier for the Angus, 7.3 lb. for the Charolais x Angus crosses and 6.1 lb. for the Holstein x Angus crosses.

TABLE 3. BIRTH WEIGHT; PREWEANING ADG; WEANING WEIGHT, GRADE AND CONDITION SCORES BY BREED COMPOSITION AND YEAR

Sire Breed	Dam Breed	Year	Birth Weight	No. Head	Adj. ADG	Adj. 205-d. Weight	Wean Grade
Ang	Ang	1970	63.5	23	1.87	448	13.1
		1971	57.5	22	1.88	444	11.6
		1972	68.2	34	1.93	465	11.8
		1973	62.4	27	2.12	498	13.0
		1974	66.6	23	2.12	503	13.0
		1975	66.2	17	1.82	441	12.1
		Combined	64.2	146	1.97	470	12.4
Char	Char	1971	90.7	6	2.22	546	11.9
		1972	85.3	9	2.16	529	12.7
		1973	90.7	9	2.13	529	12.5
		1974	82.4	8	2.09	513	12.9
		Combined	86.3	35	2.13	524	12.5
Char	Ang	1970	80.0	16	2.24	541	12.6
		1971	74.0	40	1.96	478	13.0
		1972	79.3	25	1.94	477	13.2
		1973	76.6	26	2.22	534	13.7
		1974	82.2	19	2.23	540	14.4
		1975	78.8	18	2.13	516	14.0
		Combined	77.7	144	2.09	508	13.4
Hol	Ang	1970	77.8	28	1.96	480	9.8
		1971	70.3	25	1.86	453	9.6
		1972	74.6	29	1.83	450	10.2
		1973	76.8	26	2.10	509	12.5
		1974	75.1	14	2.14	515	12.4
		1975	76.5	20	2.05	497	12.1
		Combined	75.2	142	1.97	480	10.9

Preweaning ADG and Adjusted Weaning Weights and Grades

These data are shown in table 3 by breed composition and year. Preweaning ADG, 205-day weaning weight and weaning grade fluctuated over the years for each of the groups. These environmental differences were expected since some seasons were more favorable to cattle production than others. The composition of the cow herds changed very little, with the exception of the straightbred Charolais herd, since no additional cattle were added to the herds after the 1968 heifer crop and cows were culled only for failing to produce a calf, becoming crippled or, in a few cases, where they were extremely thin due to very old age.

As can be seen from table 3, there was no difference in adjusted ADG from birth to weaning of the calves sired by Angus and Holstein bulls.

Calves sired by Charolais bulls averaged about .10 lb./day faster growth than the other groups, with the exception of the straightbred Charolais which averaged .16 lb./day faster than the straightbred Angus and Holstein x Angus calves. Because of the lighter birth weights, the Angus calves were the lightest of all groups at weaning time, being only 10 lb. lighter than the Holstein cross calves, but 38 lb. lighter than the Charolais cross calves and 54 lb. lighter than the straight Charolais calves. There was no difference in the average grades of the straightbred Angus and straightbred Charolais calves, but the Charolais x Angus cross calves graded about 1 grade point higher and the Holstein cross calves about 1.5 grade points lower than the straightbred Angus calves.

Summary

Fertility and pre-weaning performance data are presented for six calf crops at the Southampton Farm comparing both straightbred and crossbred calves involving Angus and Charolais cows and bulls representing the Angus, Charolais and Holstein breeds. There were a total of 618 matings and 511 calves weaned.

Percent of calves weaned to cows exposed were 83.3, 82.7, 81.5 and 83.3 for the Angus, Charolais, Charolais x Angus and Holstein x Angus groups, respectively. Fertility was highest for the crossbred matings but the advantage was lost by a larger number of calf losses, particularly at birth, among the crossbreds. Calving difficulty was not great among any of the groups but cow deaths were largest in the Charolais x Angus group and calf losses greatest among both crossbred groups.

Average birth weights were 64.2, 86.3, 77.7 and 75.2 pounds for the Angus, Charolais, Charolais x Angus, and Holstein x Angus groups, respectively. There was no difference in adjusted average daily gains (ADG) of Angus and Holstein x Angus calves (1.97 lb./day) which was less than for the Charolais (2.13 lb./day) and the Charolais x Angus (2.09 lb./day) calves. Adjusted 205-day weights paralleled the adjusted ADG's. They were 470, 524, 508 and 480 pounds for the Angus, Charolais, Charolais x Angus and Holstein x Angus, respectively.

Weaning grades were in favor of the Charolais x Angus crossbreds (13.4) and lowest for the Holstein x Angus crossbreds (10.9). The straightbred Angus and Charolais were intermediate (12.4 and 12.5).

PROGRESS REPORT ON COW BREED EVALUATION AT SOUTHAMPTON FARM

T. J. Marlowe, E. M. Grizzard[1] and W. E. Burgess[2]

This cooperative research is objective 2 described in another manuscript in this Annual Report entitled "Fertility and Calf Performance to Weaning at Southampton Farm." Specifically, this objective is to evaluate the straightbred and crossbred females saved from the sire evaluation phase of this project when mated either to bulls of the same breed and/or bulls of still another breed.

Source of Cattle, Management and Mating Schemes

Source of cattle

Both straightbred and crossbred heifer calves were saved from each of the first five calf crops of the sire breed evaluation phase to be used as the foundation females for the cow breed evaluation phase of the project. All calves except the straightbred Charolais were weaned in May and placed on grass-legume pasture and fed once daily approximately one percent of their body weight of a supplement consisting of 3 parts corn to 1 part SBOM. Because of a difference in calving season the Charolais heifers were weaned in late July, placed on pasture and treated the same as the other heifers thereafter.

All heifers were re-weighed and scored for conformation and condition at approximately one year of age, usually the last week of October for the Angus and crossbred heifers and February for the straightbred Charolais heifers. Approximately equal numbers of the four kinds of heifers were selected each year, based on their 365 day weight, to go into breeding herds for the cow breed evaluation phase except that some additional Angus heifers were kept for the purpose of having twice as many straightbred Angus heifers as each of the other groups. The reason for the extra Angus heifers was to have one herd bred as straight Angus and the other herd bred the same as the crossbred heifers.

Mating scheme

All heifers were exposed to an Angus bull, except the straightbred Charolais heifers which were exposed to a Charolais bull, so as to calve at two years of age. Thereafter, one half of the Angus heifers and all of the Charolais x Angus and Holstein x Angus heifers were exposed each year to Simmental x Hereford crossbred bulls. The other half of the Angus heifers were bred to Angus bulls to provide a straightbred Angus control herd. The Charolais heifers were bred to Charolais bulls to provide a straightbred control Charolais herd.

The number of matings for the years 1971 through 1975 and the planned matings for the future are shown in table 1.

[1,2] Farm director and herdsman, respectively.

TABLE 1. MATING SCHEME FOR COW BREED EVALUATION PHASE AT SOUTHAMPTON FARM

Calving at 2 Years of Age

Sire Breed		Angus			Charolais
Heifer Breed		Angus	Char x Ang	Hol x Ang	Charolais
Year	1971	5	5	5	2
	1972	8	8	8	6
	1973	6	6	6	6
	1974	14	10	10	6
	1975	10	5	5	7
	1976	10	5	5	8
Total 1st Matings		53	39	39	35

Calving at 3 Years and Older

Sire Breed		Angus	Simmental x Hereford			Charolais
Cow Breed		Angus	Angus	Char x Ang	Hol x Ang	Charolais
Year	1972	7	7	7	7	5
	1973	18	16	17	16	7
	1974	14	18	18	20	12
	1975	25	27	26	28	28
	1976	32	28	30	28	34
Total Matings		96	96	98	99	86

Results and Discussion

The data are presented in tables for convenience in making comparisons. They include fertility, cow and calf losses, calves weaned, birth weight, and weaning weight and grade.

Fertility and calving percentage

These data are presented in table 2 for heifers calving as 2 year olds and in table 3 for the Phase II cows at three, four and five years of age. An average of 28 heifers for each of the four types were exposed to bulls over a four year period (1971-1974) and the following percent calf crops were weaned: Angus, 75.8; Charolais, 59.1; Charolais x Angus, 75.9; and Holstein x Angus, 89.7. These data have not been analyzed statistically but it is obvious that the Holstein x Angus cows were superior to the other three breed types. Of the 111 heifers bred as yearlings to calve as 2 year olds, 84 weaned calves for a calving percentage of 75.7. There were more open heifers among the straightbreds (12 vs 7). Only five calves were lost, four of which were from straightbred matings. One heifer was lost in each of the Angus, Charolais and Charolais x Angus cross groups.

All heifers were again exposed to bulls following their calving as two year olds. The Charolais heifers were exposed only to Charolais bulls. One half of the Angus heifers were exposed to Angus bulls. The remaining half of the Angus heifers plus all of the Charolais x Angus and Holstein x Angus crossbred heifers were exposed to Simmental x Hereford bulls. The latter breeding scheme was followed thereafter.

The fertility data are shown in table 2 for heifers and table 3 for cows. The calf crop percentages weaned from the straightbred cows were 79.5 and 80.5 for the Angus and Charolais, respectively. For the three groups of cows bred to Simmental x Hereford bulls they were: 73.2 for Angus, 78.6 for Charolais x Angus, and 86.0 for the Holstein x Angus cows. Again, it is obvious that the Holstein x Angus cows were generally more fertile with no significant difference among the other groups except that the straightbred Angus cows bred to Simmental x Hereford bulls weaned the smallest percentage of calves of any of the groups. Of the 206 cows exposed to bulls,164 or 79.6% weaned calves. Of the 19 open cows only

TABLE 2. COW BREED EVALUATION: FERTILITY AND CALVES WEANED FROM TWO-YEAR-OLD HEIFERS AT SOUTHAMPTON FARM

Breed of		Number of Heifers			Calves	Calves Weaned	
Heifer	Year	Exposed	Open	Died	Lost	Number	Percent
Angus	1972	5	1	0	1	3	60.0
	1973	8	3	0	1	4	50.0
	1974	6	2	0	0	4	66.7
	1975	14	0	1	0	14	100.0
	Sub Total	33	6	1	2	25	75.8
Charolais	1972	2	1	0	0	1	50.0
	1973	6	2	1	1	2	33.3
	1974	6	2	0	0	4	66.7
	1975	6	1	0	1	4	66.7
	Sub Total	20	6	1	2	11	59.1
Char x Ang	1972	5	2	0	0	3	60.0
	1973	8	2	0	1	5	62.5
	1974	6	0	1	0	4[2]	66.7
	1975	10	0	0	0	10	100.0
	Sub Total	29	4	1	1	22	75.9
Hol x Ang	1972	5	0	0	0	5	100.0
	1973	8	1	0	0	7	87.5
	1974	6	2	0	0	4	66.7
	1975	10	0	0	0	10	100.0
	Sub Total	29	3	0	0	26	89.7
All Heifers	Totals	111	19	3	5	84	75.7

See footnotes on next page

[1]All heifers were bred to Angus bulls except that Charolais heifers were bred to Charolais bull.

[2]One cow gave no milk so her calf was not counted as weaned.

TABLE 3. BREED EVALUATION: FERTILITY AND CALVES WEANED FROM 3, 4, & 5 YEAR OLD COWS AT SOUTHAMPTON FARM

Cow Breed	Year	Number of Cows Exposed	Open	Died	Calves Lost	Calves Weaned Number	Percent
Angus[1]	1973	7	0	0	0	7	100.0
	1974	18	5	0	0	12[3]	66.7
	1975	14	0	0	2	12	85.7
	Sub Totals	39	5	0	2	31	79.5
Charolais[1]	1972	5	0	0	1	4	80.8
	1973	7	0	0	0	7	100.0
	1974	12	2	2	1	8	66.7
	1975	17	1	0	2	14	82.3
	Sub Totals	41	3	2	4	33	80.5
Angus[2]	1973	7	0	0	2	5	71.4
	1974	16	3	0	3	10	62.5
	1975	18	0	0	3	15	83.3
	Sub Totals	41	3	0	8	30	73.2
Char x Ang[2]	1973	7	4	0	0	3	42.8
	1974	17	3	0	0	14	82.3
	1975	18	0	0	0	16	88.9
	Sub Totals	42	7	0	0	33	78.6
Hol x Ang[2]	1973	7	0	0	2	5	71.4
	1974	16	1	0	3	12	75.0
	1974	20	0	0	0	20	100.0
	Sub Totals	43	1	0	5	37	86.0
All Cows	Totals	206	19	2	19	164	79.9

[1]These cows bred to bulls of their own breed.

[2]These cows bred to Simmental x Hereford bulls.

[3]One cow gave no milk, calf not counted as weaned.

one was in the Holstein x Angus group. On the other hand, of the 19 calves lost, five were in the Holstein x Angus group, none in the Charolais x Angus, 8 in the group of straightbred Angus cows bred to Simmental x Hereford bulls, and only 2 and 4 were in the straightbred Angus and Charolais groups, respectively. Only 2 cows died and they were both straightbred Charolais.

TABLE 4. COW BREED EVALUATION: FERTILITY AND CALVES WEANED FROM HEIFERS AND COWS COMBINED, 1972-1975

Kind of Cow	Cow Age Group	Number of Cows Exposed	Number of Cows Open	Number of Cows Died	Calves Lost	Calves Weaned Number	Calves Weaned Percent
Angus[1]	2 yr. olds	33	6	1	2	25	75.8
	3-5 yrs.	39	5	0	2	31	79.5
	Sub Totals	72	11	1	4	56	77.8
Charolais[1]	2 yr. olds	20	6	1	2	11	59.1
	3-5 yrs.	41	3	2	4	33	80.5
	Sub Totals	61	9	3	6	44	72.1
Angus[2]	2 yr. olds	33	6	1	2	25	75.8
	3-5 yrs.	41	3	0	8	30	73.2
	Sub Totals	74	9	1	10	55	74.3
Char x Ang[2]	2 yr. olds	29[3]	4	1	1	22	75.9
	3-5 yrs.	42	7	0	0	33	78.6
	Sub Totals	71	11	1	1	55	77.5
Hol x Ang[2]	2 yr. olds	29	3	0	0	26	89.7
	3-5 yrs.	43	1	0	5	37	86.0
	Sub Totals	72	4	0	5	63	87.5
All Cows & Heifers		317	38	5	24	248	78.2

[1]These cows were bred to bulls of their own breed.

[2]These cows were bred to Angus bulls as yearlings and to Simmental x Hereford bulls thereafter. The 2 yr. olds are the same as the 2 yr. olds under Angus at top of table.

[3]One cow in this group gave no milk so her calf was not counted as weaned.

These data are shown for each cow group of all ages in table 4. Calving percentages weaned for the two straightbred groups were 77.8 for Angus and 72.1 for Charolais. For the cows bred to Simmental x Hereford bulls the percent calves weaned was 74.3 for Angus cows, 77.5 for Charolais x Angus cows, and 87.5 for the Holstein x Angus cows. Of the 317 cows exposed 38 cows were open, 24 calves were lost, 5 cows died and 248 calves were weaned for a 78.2% total calf crop. Looking again at open cows, calves lost and cows that died for each of the cow groups we see that there were 11 cows open in each of the straightbred Angus and the Charolais x Angus groups, 9 each in the straightbred Charolais and the Angus bred to Simmental x Hereford bulls and only 4 in the Holstein x Angus cow group. Calf losses were greatest for the straightbred Angus cows bred to Simmental x Hereford bulls followed by about one half as many losses in the Charolais and Holstein x Angus cow groups, with the straightbred Angus and Charolais groups being intermediate and the Charolais x Angus cows losing only one calf. Only two cows died from the 206 matings among the 3-5 year-old cows. They were both straightbred Charolais cows. Fertility data by kind of cow (crossbred vs straightbred) are shown in table 5. Fertility was considerably higher among the crossbred heifers (82.8 vs 65.4%) and somewhat higher among the crossbred cows (82.3 vs 77.7%).

TABLE 5. COW BREED EVALUATION: CROSSBREDS VS STRAIGHTBREDS FOR FERTILITY AND CALVES WEANED

Cow Breed	Cows Exposed	Cows Open	Calf Losses	Cow Deaths	Calves Weaned Number	Calves Weaned Percent
		Heifers Calving as 2 Year Olds				
Crossbreds	58	7	1	1	48	82.8
Straightbreds	55	12	4	2	36	65.4
		Cows Calving as 3-5 Year Olds				
Crossbreds	85	8	5	0	70	82.3
Straightbreds	121	11	14	2	94	77.7
		Heifers and Cows Combined				
Crossbreds	143	15	6	1	118	82.5
Straightbreds	176	23	18	4	130	73.9

Based on four calf crops, 1972-1975.

Birth weights

The birth weights of calves out of the 2-year-old heifers were considerably less than calves out of 3-5-year-old cows, except for the straightbred Charolais, which were essentially the same weight for both cow age groups. For example, the birth weights of calves from 2-year-old heifers and 3-5-year-old cows were as follows: 54.0 and 68.4 for Angus, 86.7 and 87.3 for Charolais, 62.6 and 79.5 for Charolais x Angus and 63.1 and 80.3 for Holstein x Angus. It should be kept in mind that the older Charolais x Angus and Holstein x Angus were mated to Simmental x Hereford bulls, whereas the young cows were mated to Angus bulls. However, when we compare the older Angus cows that were mated to either Angus or Simmental x Hereford bulls there was no difference in birth weight of calves. Birth weights by breed of sire and dam are shown in table 6 for 2-year-old cows and in table 7 for 3-5-year-old cows.

There was no significant difference in birth weight of crossbred and straightbred calves. However, the straightbred Angus and the Simmental-Hereford x Angus calves were considerably lighter than the other groups; whereas, the straightbred Charolais calves were heavier than all others for both cow age groups.

Preweaning ADG and adjusted weaning weights and grades

These data are shown in table 6 by breed composition and year for the 2-year-old heifers and in table 7 for the 3-5-year-old cows. They are further summarized by crossbreds vs straightbreds for both age groups combined in table 8. In all cases, the crossbred heifers and cows out-performed the straightbred heifers and cows. There was very little difference in calf performance from 3-5-year-old Angus cows regardless of whether they were mated to Angus or Simmental x Hereford bulls.

Angus calves had the lowest adjusted ADG and the lowest adjusted 205-day weight. However, it seemed to make little difference whether the Angus cows were bred to Angus bulls or to Simmental x Hereford bulls. Charolais calves were intermediate in adjusted ADG and 205-day weight. When the offspring performance of both heifers and cows was combined the crossbreds had an advantage of .20 lb./day gain from birth to weaning and a 38 lb. advantage at 205 days of age. They also graded .8 a grade point higher than the straightbreds.

TABLE 6. BIRTH WEIGHTS; PREWEANING ADG; WEANING WEIGHT AND GRADE FOR HEIFERS CALVING AS TWO-YEAR-OLDS BY BREED COMPOSITION AND YEAR

Sire Breed	Dam Breed	Year	Birth Weight	No. Head	Adj. ADG	Adj. 205-Day Wt.	Wean Grade
		Heifers Calving as 2 Year Olds					
Ang	Ang	1972	49.0	3	1.62	382	9.8
		1973	51.0	4	2.02	466	11.7
		1974	51.4	4	1.90	441	10.9
		1975	56.9	13	1.82	430	13.0
		Average	54.0	24	1.84	432	12.0
Char	Char	1971	97.0	2	2.38	585	12.2
		1973	90.0	2	2.09	520	12.4
		1974	80.0	4	1.75	441	11.8
		Average	86.7	8	1.99	497	12.0
Ang	Char x Ang	1972	76.7	3	1.76	432	12.7
		1973	58.4	5	2.15	500	12.9
		1974	58.2	4	1.96	460	12.2
		1975	62.2	10	2.02	477	13.8
		Average	62.6	22	2.00	473	13.2
Ang	Hol x Ang	1972	62.8	5	1.93	460	12.1
		1973	58.2	7	2.14	498	11.5
		1974	65.5	4	2.15	507	13.1
		1975	65.8	10	2.25	527	13.5
		Average	63.1	26	2.14	503	12.6

TABLE 7. BIRTH WEIGHT; PREWEANING ADG; WEANING WEIGHT AND GRADE FOR 3-5-YEAR-OLD COWS BY BREED COMPOSITION AND YEAR

Sire Breed	Dam Breed	Year	Birth Wt.	No. Head	Adj. ADG	Adj. 205-Day Wt.	Wean Grade
Ang	Ang	1973	64.3	7	2.02	488	12.0
		1974	70.3	12	2.09	498	12.9
		1975	68.8	12	1.90	461	14.5
		Average	68.4	31	2.00	481	13.3
Char	Char	1972	85.0	4	2.12	521	12.6
		1973	92.3	7	2.22	548	13.1
		1974	84.7	8	2.11	518	12.5
		Average	87.3	18	2.15	529	12.7
SmH	Ang	1973	52.8	5	2.02	468	12.5
		1974	67.6	10	2.00	480	12.3
		1975	74.1	15	2.08	502	12.7
		Average	68.4	30	2.04	489	12.5
SmH	CharxAng	1973	82.5	3	2.57	610	13.7
		1974	82.6	14	2.20	534	13.5
		1975	76.2	16	2.16	520	13.4
		Average	79.5	33	2.21	534	13.5
SmH	Hol x Ang	1973	69.4	5	2.46	574	13.3
		1974	81.0	12	2.33	562	13.7
		1975	82.6	20	2.38	571	13.8
		Average	80.3	37	2.37	568	13.7

TABLE 8. CROSSBRED VS STRAIGHTBRED COWS ON CALF PERFORMANCE TO WEANING, UNWEIGHTED AVERAGES

Cow Breed	Number Calves	Birth Weight	Adj. ADG	Adj. 205-Day Wt.	Wean Grade
		Heifers Calving as 2 Year Olds			
Crossbreds	48	62.8	2.07	488	12.9
Straightbreds	32	70.3	1.91	464	12.0
		Cows Calving as 3-5 Year Olds			
Crossbreds	70	79.9	2.29	551	13.6
Straightbreds	79	74.7	2.06	500	12.8
		Heifers and Cows Combined			
Crossbreds	118	71.3	2.18	520	13.2
Straightbreds	111	72.5	1.98	482	12.4
Differences		-1.2	.20	38	.8

Summary

Fertility and preweaning performance data are presented for four calf crops under the "cow breed evaluation phase" of the cooperative research at Southampton Farm. These data compare crossbred and straightbred calves from straightbred Angus and Charolais cows and crossbred Charolais x Angus and Holstein x Angus cows. There were a total of 317 matings, 111 heifers being bred for the first time as yearlings to calve as two year olds and 206 cows being bred to calve as 3, 4 and 5 year olds.

Calving percentages for the five breed groups, based on the combined value of heifers and cows, were: 77.8% for straight Angus matings, 72.1% for straight Charolais matings, 74.3% for Angus cows mated to Simmental x Hereford bulls, 77.5% for Charolais x Angus cows and 87.5% for Holstein x Angus cows. Although the data were not analyzed statistically, it is obvious that the Holstein x Angus cows were the most fertile and the Charolais cows the least fertile with the Angus and Charolais x Angus cows being intermediate. Percent calves weaned for all cow groups was 75.7 for the heifers and 79.9 for the 2-5-year-old cows. Calving difficulties were not serious in any group. However, a higher percentage of calves were lost among the 3-5-year-old cows than among the heifers. Calf death losses was 4.5% among the heifers calving as two year olds and 9.2% among the 3-5-year old cows. Greatest calf death losses were from the Angus cows bred to Simmental x Hereford bulls (19.5%) followed by the straight Charolais (nearly 10%) and the Folstein x Angus cows (11.6%).

Crossbred cows out-performed straightbred cows both as heifers and as 3-5-year-old cows. This difference amounted to .20 lb./day in gains from birth to weaning, 38 lb./calf at 205 days and .8 grade points in weaning grade. The top-performing calves were out of Holstein x Angus cows with an adjusted ADG of 2.37 and 568 lb. at 205 days. These were followed by Charolais x Angus cows and straight Charolais cows with the straightbred Angus calves having the lowest performance of 2.00 adjusted ADG and 481 lb. at 205 days.

RELATION OF INBREEDING TO CHROMOSOMAL ABNORMALITIES IN LABORATORY MICE

G. A. Bucher and T. J. Marlowe

It is well known that high levels of inbreeding have a depressing effect on fertility and livability of the young in several species of animals. It has also been shown that chromosomal abnormalities of various types are associated with early embryonic mortality.

The purpose of the study reported here was to determine the relationship, if any, between chromosomal abnormalities and high levels of inbreeding in the laboratory mouse.

Materials and Methods

Mice were obtained from the colony maintained by the Dairy Science Department of Virginia Polytechnic Institute and State University. The inbred lines were developed from a large outbred population of ICR albino mice which were originally obtained from the Institute of Cancer Research, Philadelphia. In the production of the inbred lines, litters were sexed and randomly standardized to eight offspring and individual mice were identified by toe clipping, weaned at 21 days and randomly assigned to cages with the restriction that each cage must contain mice from more than one litter. They were reared and maintained in the Dairy Science Department Mousery. Males and females were put together at eight weeks of age and checked daily for the vaginal plug. After mating, females were seperated from the other mice and placed in individual boxes. After the birth of a litter all siblings were numbered, weaned at three weeks of age and the males and females placed in seperate boxes. All mice were sacrificed at approximately 14 weeks of age.

Prior to being sacrificed each animal was injected intraperitoneally with .03 ml. of mg./ml. stock solution of Velban one and one-half hours prior to sacrificing. Following death the femur was cut out, the muscle removed from the bone and the proximal and distal ends of the femur were removed with a pair of scissors to allow good entrance to the bone marrow. Three ml. of 1% sodium citrate solution was used to flush out the bone marrow into a small test tube. The contents of the tube were thoroughly and carefully mixed by agitating the test tube and then incubated for 20 minutes at 37°C. Following incubation the test tube was centrafuged for two to three minutes at 200 to 200 rpm. and the supernatant removed and discarded. Then, one to two ml. of fresh methanol:acetatic acid (3:1) were added to the tube, the contents shaken gently and then allowed to stand for 30 minutes, after which the contents were again mixed gently and centraguded for 5 minutes at 300 rpm. The supernatant was discarded and 1 ml. of fixative (consisting of 1 part of glacial:acetatic acid and 3 parts absolute methyl alcohol) was added. Drops of this suspension were placed on clean slides at 54°C. and allowed to air dry. The dried slides were stained with a stock solution of giemsa for 15 minutes and then run through a series of 5 baths, of which the first three were absolute acetone and the last two were zylene. The slides were kept beneath each bath for three seconds and then air dried. After the slides were dried a cover slip was mounted with permont.

All slides were carefully and systematically scanned under a Nikon microscope at 100 X magnification. Chromosome counts were made of the first 24 intact cells that had good dispertion of the chromosomes and distinctiveness of chromosome number. Animals for which 24 cells could not be counted were not included in the statistical analyses.

Twenty animals were selected at random from each of the four levels of inbreeding (0, 50, 73, and 90 percent), with the exception that only 13 animals were available for the 73% level of inbreeding.

Cells with an irregular number of chromosomes, such as 2N+1 or 2N-1, etc., were recorded as aneuploid and those with any multiple of chromosome number above the diploid number were recorded as polyploid.

Since the major objective was to determine if the percentage of normal chromosomes differed at the different levels of inbreeding, actual counts of normal cells were converted to percentages; i.e., the number of normal cells among the 24 cells counted were divided by 24 for each of the 73 mice to obtain the percentage of normal cells per mouse in each level of inbreeding. An arc-sin transformation was made of the percentage values and used in an analysis of variance of between and within levels of inbreeding to obtain the F ratio.

Results and Discussion

The number of normal, aneuploid, polyploid, and total abnormal cells for each level of inbreeding are presented in table 1. The percent of normal cells by level of inbreeding, along with their means and standard deviations, are shown in table 2.

TABLE 1. CHROMOSOME CLASSIFICATION FROM BONE MARROW CULTURES

Level of Fx	Normal	Aneuploid	Polyploid	T. Abnormal
0	367	105	8	113
50	298	169	13	182
73	222	89	3	90
90	347	122	11	133

TABLE 2. PERCENT NORMAL, MEANS AND STANDARD DEVIATIONS BY LEVEL OF INBREEDING

Level of Fx	% Normal	Mean	Standard Deviation
0	76.5	18.35	2.62
50	62.1	14.90	3.46
73	71.1	17.08	2.36
90	72.3	17.35	3.15

A modal class of 40N chromosomes was found for all mice even though there was considerable variation within each group. Of the 480 cells counted from the non-inbred line, there were 367 cells with chromosome counts of 2N=40, 105 aneuploid cells and 8 polyploid cells for 23.5% abnormals. The range of abnormality per animal was from 8.3 to 50.5 percent. Mice with 50% inbreeding produced 298 cells with chromosome counts of 2N=40, 169 aneuploid cells, and 14 polyploid cells based on a total count of 480 cells, or 37.9% irregulars. The range per animal was from 20.0 to 50.0%. At the 73% level of inbreeding only 13 animals with countable cells were available. Of the 312 total counts 222 were normal and 90 were abnormal, resulting in 28.8% abnormals. The range per mouse was from 12.5 to 45.8%. In the most highly inbred line (11 generations of half sib matings) there were 347 normal, 122 aneuploid, and 11 polyploid cells among the 480 counted. This resulted in a 27.7 percent level of abnormalities with a range per animal from 0.0 to 58.3 percent.

It is obvious from looking at these percentages of normal and/or abnormal cells that the relationship is not linear. There was a particularly high incident of abnormal chromosomes at the 50% level of inbreeding.

An analysis of variance was run to determine if the percentage of normal cells for each level of inbreeding (table 2) differed significantly. This analysis of variance is shown in table 3. The analysis was first run using the individual percentage values for each of the 73 mice and an F ratio of 4.75 was obtained. An arc-sin transformation was then made of the percentage values and another ANOVA was run and an F ratio of 4.38 obtained. Looking up these values in an F ratio table with 3 and 73 degrees of freedom each of these values is significant at the .01 level of probability.

TABLE 3. ANALYSIS OF VARIANCE BASED ON ARC-SIN-TRANSFORMATION OF THE PERCENTAGES OF NORMAL CELLS

Source of Variation	Degrees of Freedom	Sum Of Squares	Mean Squares	F Ratio
Among Levels of Inbreeding	3	961.60	320.53	4.38^{**}
Within (error)	69	5052.01	73.22	

$^{**}P<.01$

As one looks at the percentage of normal cells by levels of inbreeding it is obvious that the 50% level of inbreeding is contributing the major portion of the variation. In fact, the 50% level was significantly different from each of the other levels, but the other levels were not significantly different from each other.

The overall mean of the aneuploid type cell frequency per animal was 28.7%, which is higher than the 18.0% reported by Feckheimer (1961) from counts of spermatogonia cells from non-inbred mice and about three times as high as the counts of somatic chromosomes from non-inbred cattle reported by Herschler et al (1962). Most of the anueploid cells fell within the range of 38 to 42 chromosomes.

It appears from these findings that inbreeding enhances the probability of certain types of mitotic aberrations giving rise to aneuploid cells of the bone marrow. Other workers have reported a tendency for non-disjunction to be inherited in certain human families. The exact reason for this highly significant difference in number of abnormal chromosomes at the 50% level of inbreeding cannot be determined from this study. However, it would appear that at some level of inbreeding equal to or lower than 50% there is a significant increase in chromosomal abnormalities. It is unfortunate that we did not have mice at lower levels of inbreeding to see if the number of abnormalities might be even higher. It is conceivable that during the early generations of inbreeding the embryos with abnormal compliments of chromosomes carrying deleterious genes die off leaving only those with few or no abnormal chromosomes for future generations. Another possibility is that the animals surviving at the higher levels of inbreeding were actually not more homozygous but were more heterozygous because of chance combinations of genes and chromosomes.

Summary

Laboratory mice were produced to obtain 0, 50, 73 and 90 percent levels of inbreeding. At 14 weeks of age 20 mice at each level (except the 73% level where only 3 mice were sacrificed) were sacrificed, bone marrow samples obtained from the femur, incubated and prepared for scanning for chromosome abnormalities under a microscope at 100 X magnification. Twenty-four cells were counted for each of the 73 mice and recorded as being normal, aneuploid, or polyploid in type. The percentages of abnormal cells counted, by level of inbreeding, were 23.5, 37.9 , 28.8 and 27.7 for the 0, 50, 73 and 90 percent levels of inbreeding, respectively. The range of abnormal cells from individual animals varied from 0 to over 50%.

An analysis of variance based on the arc-sin-transformation of the percentage of normal cells gave an F-ratio of 4.38, which is significant at the .01 level of probability. When the various levels were compared, it was found that the 50% level of inbreeding was significantly different from each of the other levels but the other levels were not significantly different from each other. It would appear, therefore, that inbreeding does have a significant effect on the total number of chromosomal abnormalities. The relationship is not linear, however, and the fact that the significant difference was at the 50% level makes it difficult to explain. Perhaps the level of abnormalities had reached a peak by the time the population was 50% inbred and those animals with the highest levels of abnormalities have died off leaving only those with few or no abnormalities for future generations.

* * * * * * *

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A COMPARISON OF RATIONS FOR SUCKLING LAMBS ON HEAVILY STOCKED PERMANENT PASTURES

J. S. Copenhaver, R. C. Carter, F. S. McClaugherty
W. B. Williams and T. L. Bibb

Previously reported work (Livestock Research Report, 1972-73, page 51) has shown that suckling lambs make very good gains on permanent bluegrass, orchardgrass, fescue and white clover pasture when they are stocked at rates as high as 6-8 ewes and 8-10 lambs per acre. Lambs fed a pelleted creep ration produced satisfactory but costly gains.

In 1973, a 2-year test was initiated to compare rations for suckling lambs on pasture to determine which ration would produce the highest gain at the lowest cost. The rations tested were:

1. A pelleted ration (16% protein) consisting of 25% mixed alfalfa hay, 13% soybeam meal (44%), 5% molases, 56% corn and 1% vitamins and minerals. This ration was fed in a creep and is the same ration that was used in previous work.

2. A 12% ground corn-soybean meal ration fed in a creep and limited fed.

3. A 16% ground corn-soybean meal ration fed in a creep and limited fed.

A group of western ewes and their lambs were divided into five groups and randomly assigned to grazing lots at the stocking rate of 6 ewes and 10 lambs per acre. Ewes and lambs were treated for internal parasites, weighed and put in the lots April 12, 1973 and April 16, 1974. Lambs were weighed and drenched at 21-day intervals with alternate treatments of Loxon and Tramisol; ewes were weighed and treated at 42-day intervals. Lambs on limited fed rations received 1 lb. feed/lamb/day in a trough and the creep fed ration was kept before the lambs in a creep feeder. Lambs were removed from the lots as they reached market weight (95 lbs.) and those remaining were removed 8/16/73 and 8/14/74. The results are shown in Table 1.

Table 1. COMPARISON OF RATIONS FOR SUCKLING LAMBS ON PASTURE 1973-74

	12% Corn-Soybean Meal		16% Corn-Soybean Meal		16% Pellets
How fed	Limited	Creep	Limited	Creep	Creep
Ewe Performance:					
Av. no. ewes/acre	6	6	6	6	6
ADG-lb.	-.064	-.008	-.021	+.003	-.05
Lamb Performance:					
Av. no. lambs/acre	10	10	10	10	10
Initial wt. lb.	35	36	36	36	34
ADG-lb.	.40	.48	.41	.50	.61
Concentrate/day lb.	.90	1.81	.89	1.83	2.21
Concentrate/lb.gain	1.31	3.04	3.02	3.41	3.72
Concentrate cost/ pound gain	11.5¢	14.1¢	18.4¢	18.0¢	18.8¢

Cost based on: 1973 Corn 2.7¢/lb. SOM 7.8¢/lb. Pellets 4.3¢/lb.
1974 7¢/lb. 8¢/lb. 5.9¢/lb.

There were considerable differences in rate of gain and feed cost per pound of gain. The lambs on the pelleted feed made much better gains than those on other rations, but the feed cost per pound of gain was high. The lambs on the 12% limited rations showed the lowest feed cost per pound of gain, but gains were less than satisfactory.

A TWO-YEAR COMPARISON OF FORTIFIED CORN SILAGE AND ALFALFA HAY (MIXED) FOR WINTERING EWES

J. S. Copenhaver, R. C. Carter and W. B. Williams

One year's results of this comparison was reported in the 1974 Livestock Research Report. These results indicate that fortified corn silage is equal to supplemented alfalfa hay for wintering pregnant ewes but the lambs nursing the silage fed ewes did not gain as rapidly as those nursing the hay fed ewes.

The silage used in 1975 was made from frosted corn that was too dry when ensiled and the hay was better than that used in 1974 so the amounts fed per ewe were changed to compensate for this difference.

The treatments were:
Treatment 1 (Control). Prior to lambing in 1974, this group of ewes were fed 3 3/4 lb. of second-cutting alfalfa-orchard grass hay and 1 lb. of corn and cob meal per head/day. After lambing they received 4 lb. of hay plus 2 lb. of corn and cob meal daily. In 1975 the pregnant ewes were fed 3 lb. of second-cutting alfalfa-orchard grass hay and 1 1/2 lb. of corn and cob meal. The lactating ewe received 3 lb. of hay and 2 1/4 lb. of corn and cob meal.

Treatment 2 (Supplemented Silage). In 1974 this group of ewes were fed 3/4 lb. of corn and cob meal, 6 lb. of corn silage (same silage as Treatment 3) and 1/2 lb. of soybean oil meal (44%) per ewe/day prior to lambing and 1 lb. of corn and cob meal, 9 lb. of silage and 1/2 lb. of soybean oil meal after lambing. In 1975 they received 3/4 lb. corn and cob meal, 4 1/2 lb. of corn silage and 1/2 lb. of soybean oil meal before lambing and 1 lb. of corn and cob meal, 6 lb. of corn silage and 1/2 lb. of soybean oil meal after lambing.

Treatment 3 (Corn Silage). These ewes were fed all of the fortified corn silage they would eat before and after lambing. The silage was made from 150 bu/acre corn with 20 lb. urea, 10 lb. ground limestone, 4 lb. di-calcium phosphate and 5 lb. of gypsum added per ton of silage as it was ensiled. The 1975 silage was made from similar corn except that it was frost-bitten and very dry. The silage tested 39% dry matter in 1974 and 50% in 1975. Table 1 shows rations fed in these treatments.

Sixty western ewes of Suffolk x Rambouillet breeding were assigned to this test. Four weeks prior to expected lambing (Feb. 15) the ewes were weighed and divided into three similar groups according to body weight and the groups were randomly assigned to treatments.

The ewes were weighed weekly before lambing and ewes and lambs were weighed weekly after lambing and at the end of the test. The test was completed 4/3/74 and 4/9/75. None of the lambs were creep fed. The results of this test are found in Table 2.

The lambs from the hay and supplemented silage fed ewes gained considerably faster than those from the ewes on silage. These two groups of lambs had access to some grains by eating with their dams and this could account for some or all of the difference in gain. The lambs from the silage fed group showed the lowest feed cost per pound of gain.

TABLE I. RATIONS FED 1974 and 1975 - POUND/DAY

	GESTATION						LACTATION					
	Hay		Supp. Sil.		Silage		Hay		Supp. Sil.		Silage	
Year	74	75	74	75	74	75	74	75	74	75	74	75
Alfalfa Hay (mixed) lb.	3.75	3.0					4.0	3.0				
Corn silage lb.			6.0	4.5	9.2	8.0			9.0	6.0	11.9	9.5
Corn & cob lb.	1.0	1.5	.75	.75			2.0	2.25	1.0	1.0		
SOM lb.			.5	.5					.5	.5		
Total lb.	4.75	4.5	7.25	5.75	9.2	8.0	6.0	5.25	10.5	7.5	11.9	9.5
Feed Cost per day (¢)	12.0	12.1	12.1	10.5	8.7	8.0	16.1	14.8	15.8	12.9	11.2	9.5

Cost based on: Hay, $45/ton; Corn, $2.50/bu.; SOM, $150/ton; Silage (1974) $18.80/ton and Silage (1975) $20.00/ton.

TABLE 2. TWO YEAR COMPARISON OF CORN SILAGE AND HAY FOR WINTERING EWES

	HAY	SUPP. SILAGE	SILAGE
Total ewes exposed	40	40	40
No. lambing	40	40	40
Lambs born	84	80	78
Lambs raised	68	62	62
Av. birth wt./lb.	9.5	9.5	9.8
ADG (lamb) lb.	.51	.53	.43
Lbs. lamb/ewe	52.3	51.1	41.8
Ewe wt. on test	176	176	176
Ewe gain to lambing	24	25	21
Loss from lambing	37	34	35
Final Wt./lb.	158	160	151
Feed cost/lb. lamb	20.2¢	21.2¢	15.5¢

Cost based on: Hay, \$45/ton; Corn, \$2.50/bu.; SOM, \$150/ton; and Silage \$20/ton.

ZERANOL IMPLANTATION IN GRAZING HEIFERS AND IN COMBINATION WITH MELENGESTROL ACETATE IN FEEDLOT-FED HEIFERS[1]

J. P. Fontenot and R. F. Kelly

Implanting zeranol in grazing and feedlot-fed heifers has been shown to result in increased gain. In trials conducted during 1972-74, a 34 lb. improvement in pasture and feedlot gain from zeranol implants in spring and fall was reported (V.P.I. & S.U. Res. Div. Rep. 158). Melengestrol acetate (MGA), a drug which suppresses estrus in heifers has been used to improve performance in fattening cattle. An experiment was started to study the effect of using a combination of these two materials on feedlot performance of fattening heifers.

Experimental Procedure

A total of 96 heifers owned and kept on the Graves Bros. Farm, Syria, Va. were used in this experiment. The heifers were divided into groups of 8 according to weight and the heifers within each group received the following treatments:

	Treatment	
Lot no.	Spring	Fall
1	none	none
2	none	MGA
3	none	zeranol
4	none	MGA + zeranol
5	zeranol	none
6	zeranol	MGA
7	zeranol	zeranol
8	zeranol	MGA + zeranol

[1]Appreciation is expressed to Graves Bros. Farm, Syria, Va. for their cooperation; to Commercial Solvents Corp. Terre Haute, Ind. for supplying the zeranol implants and supporting, in part, this study with a grant-in-aid; and to Southern States Cooperative, Richmond, Va. for supplying the melengestrol acetate.

The heifers were grazed in two groups of 48 (6/treatment) together on native pasture from April 22 to November 27, 1974. At the end of the pasture season each of the two groups of heifers was placed in the feedlot. All of the cattle were fattened on a ration consisting of corn silage, ground ear corn and a high urea supplement. One-half of each group were fed MGA at the level of .04 mg. per pound of concentrate (ear corn and supplement) and the other treatment received no additive.

Prior to the beginning of the trial and at the end of the fattening period the cattle were individually weighed and scored for slaughter grade, mammary development and tailhead elevation. One group of cattle were weighed on February 19, 1975 and most of the cattle weighing over 800 lb. were slaughtered shortly afterwards. The other group of cattle were weighed off of experiment on March 10, 1975. The cattle were removed from the MGA supplement at least two days prior to slaughter. Data collected at slaughter were warm carcass weight, loin-eye area, backfat thickness and carcass grade.

Results

The results of the trial are given in table 1. Implanting with zeranol in the spring resulted in an average increase in pasture gain of 7 lb. per head. This is considerably less than was obtained in two previous trials (V.P.I. & S.U. Res. Div. Rep. 158).

A different number of cattle were removed from different treatments at different times during the fattening period. Therefore, feedlot and total gain are reported only until the first time some of the cattle in a group were slaughtered (Feb. 19 and Mar. 10, 1975). The zeranol implant resulted in only a small average improvement in feedlot gain. Feeding MGA increased feedlot gain 8 lb. per head.

Heifers not implanted with zeranol nor fed MGA gained 392 lb. during the grazing and feedlot phases combined (lot 1). Gains of all other treatments were higher than this, except for the heifers which were only fed MGA (lot 2). Highest total gains were for the heifers which received a zeranol implant in spring and fall and were fed MGA during the feedlot phase (lot 8). These showed a 46 lb. advantage over those not implanted nor fed MGA (lot 1). The next highest total gains were for the heifers which received both a fall zeranol implant and were fed MGA in the feedlot.

The carcasses were good to choice and there were no consistent differences in carcass characteristics among the heifers receiving the different treatments. There was no evidence of side effects such as tailhead elevation and mammary development resulting from any of the treatments.

TABLE 1. IMPLANTING ZERANOL IN GRAZING AND FATTENING HEIFERS AND FEEDING MELENGESTROL ACETATE IN FATTENING HEIFERS

Spring implant	None	None	None	None	Zeranol	Zeranol	Zeranol	Zeranol
Fall treatment	None	MGA	Zeranol	Zeranol + MGA	None	MGA	Zeranol	MGA + Zeranol
Lot no.	1	2	3	4	5	6	7	8
Weight data, lb.								
Initial wt., spring, 1974	430	380	431	444	424	418	434	429
Wt., fall	622	602	636	658	654	615	644	661
Pasture gain	190	228	206	216	230	197	210	232
Daily gain, pasture	0.86	1.04	0.94	0.99	1.04	0.90	0.96	1.06
Wt., end feedlot test	819	778	824	854	831	821	844	868
Feedlot gain	205	213	203	200	179	205	204	207
Daily gain, feedlot	2.22	2.32	2.21	2.20	1.94	2.26	2.20	2.22
Gain, pasture & feedlot	392	366	410	418	410	403	414	438
Da. gain pasture & feedlot	1.26	1.18	1.32	1.34	1.32	1.30	1.32	1.41
Tailhead elevation[a]								
Initial, spring	0.52	0.42	0.39	0.56	0.38	0.21	0.41	0.38
Fall	0.27	0.28	0.12	0.34	0.24	0.50	0.30	0.43
End feedlot test	0.28	0.29	0.32	0.10	0.34	0.42	0.21	0.51
Mammary development								
Initial	0.00	0.00	0.08	0.00	0.00	0.04	0.04	0.05
Fall	0.46	0.19	0.28	0.46	0.00	0.33	0.27	0.44
End feedlot test	0.31	0.11	0.21	0.81	0.34	0.44	0.38	0.86
Feeder grade[c]								
Initial	11.5	11.0	11.8	11.6	11.9	11.6	11.6	11.2
Fall	10.9	11.2	11.1	12.2	11.7	10.2	11.4	11.0
Slaughter grade[c]								
Initial	4.5	3.4	4.5	4.3	4.5	4.4	4.8	4.0
Fall	5.6	5.9	5.6	6.0	5.8	5.0	6.1	5.8
End feedlot test	11.2	10.8	10.9	10.9	11.0	10.8	11.4	11.8
Carcass evaluation								
Carcass grade[c]	12.0	11.8	12.0	10.0	11.5	12.3	12.0	10.8
Dressing %	56.54	57.40	56.70	55.80	56.54	56.60	56.23	56.73
Loin eye area, sq. in.	10.18	9.80	10.66	9.96	10.54	10.20	10.46	10.41
Backfat, in.	0.69	0.54	0.58	0.69	0.68	0.50	0.64	0.55

[a]Code: 0-no elevation; 1-elevation; 2-marked elevation.
[b]Code: 0-no development; 1-development; 2-marked development.
[c]Code: 9-low good; 10-avg. good; 11-high good; etc.

EFFECT OF DIETARY POTASSIUM LEVEL ON UTILIZATION OF MAGNESIUM BY SHEEP FED DIFFERENT MAGNESIUM LEVELS

T. M. Frye, J. P. Fontenot and K. E. Webb, Jr.

Magnesium supplementation in beef cows has been effective in lowering the incidence of hypomagnesemic tetany. Beef cows are more susceptible to grass tetany during lactation, when the requirement is higher than during gestation. Also during this period, additional dietary magnesium may be needed if the cows are grazing forages containing a factor that depresses magnesium utilization. Small grain pastures at a lush, actively growing stage and young spring pasture herbage frequently contain high levels of potassium. High levels of dietary potassium depress magnesium absorption, therefore bringing about a metabolic magnesium deficiency. Information on the level of dietary magnesium required to overcome the effect of high dietary potassium would be useful in determining the level of magnesium supplementation needed.

This experiment was conducted to study the effect of high dietary potassium on magnesium utilization in rations containing different levels of magnesium.

Experimental Procedure

Two metabolism trials were conducted with 24 wethers averaging 76 lb., initially. The experimental design was a 2 x 4 factorial with two levels of potassium and four levels of magnesium. The two levels of potassium were 0.7 and 4.7% potassium, dry basis. The magnesium levels were .08, .17, .33 and .61% magnesium. Prior to the beginning of the first trial, the wethers were placed in outcome groups of eight based on breeding and weight. The wethers in each group were randomly allotted to the eight treatments. The daily levels of magnesium were .5, 1.0, 2.0 and 4.0 g. per head daily. For the second trial the sheep within each outcome group were reallotted by incomplete randomization with the restriction being that no animal would receive the same ration as in trial 1.

The ingredient and chemical composition of the basal ration is shown in table 1. The shell corn and corn cob fractions were ground in a hammermill through a 1/2 in. screen. Crude protein, calcium and phosphorus were fed to meet requirements and were approximately equal among the eight rations. Magnesium and potassium levels were obtained by adding magnesium oxide or potassium bicarbonate to the basal ingredients to obtain the desired test levels. The actual magnesium and potassium levels fed for each treatment as determined by laboratory analysis are shown in table 2.

All sheep were maintained in false bottom metabolism stalls and fed one-half of the daily ration twice daily. Water was available ad libitum at all times except during the 1 hr. feeding period 7:00 to 8:00 a.m. and p.m. daily. Prior to the beginning of each trial the sheep were fed a basal ration consisting of 40.8% ground shell corn, 45.5% corn cob fraction, 12.7% soybean meal, .4% limestone and .5% trace mineralized salt. The ration contained approximately .14% magnesium.

Each trial consisted of a 5-day transition period, during which the experimental rations were introduced at the rate of 10 percentage units per feeding, followed by a 10-day preliminary period and a 10-day collection period, during which total fecal and urinary collections were made.

Feed, feces and urine were analyzed for calcium, magnesium, potassium and total phosphorus. Blood serum was analyzed for calcium, magnesium and inorganic phosphorus. Feeds and feces were analyzed for proximate components and urine was analyzed for nitrogen.

Results

Data showing the effect of dietary potassium and magnesium on magnesium balance is shown in table 3. Fecal magnesium excretion is shown in figure 1. Fecal magnesium, expressed as grams per day was linearly increased ($P < .01$) as dietary magnesium increased. The increase was similar at both potassium levels. At all levels of dietary magnesium the fecal magnesium was higher ($P < .01$) for the sheep receiving the high potassium rations. Apparent magnesium absorption, expressed as grams per day, increased linearly as dietary magnesium levels increased (figure 2). Absorption was higher ($P < .01$) for the animals receiving the low potassium rations. The high potassium level fed decreased the magnesium absorption by about the same extent, regardless of the dietary magnesium level. Apparent magnesium absorption, expressed as percent of intake, is shown in figure 3. Maximum absorption was observed at the dietary magnesium level of 1.0 g. per day (.17%) for the low potassium rations and 2 g. per day (.33%) for the high potassium ration. Absorption expressed as percent was lower ($P < .01$) for the sheep fed the high potassium rations. This effect was not as pronounced at the high dietary magnesium levels of 2.0 and 4.0 g. per day (.33 and .61) as at the lower magnesium levels. The magnesium X potassium interaction was significant ($P < .001$).

The effects of dietary potassium and magnesium levels on urinary magnesium are shown on figure 4. Urinary magnesium showed a linear increase ($P < .01$) with increased magnesium intake at both the low and high potassium levels. Urinary magnesium was reduced ($P < .01$) in animals fed the high-potassium rations, which apparently resulted from lowered magnesium absorption. Magnesium retention, expressed as grams per day, increased ($P < .01$) as magnesium level increased, within potassium levels. Blood serum magnesium is shown in figure 5. Over-all, serum magnesium showed a linear ($P < .01$) response to dietary magnesium level. Feeding high potassium resulted in a depression ($P < .01$) in blood serum magnesium. High potassium did not affect the serum level at the lower magnesium levels and lowered it at the higher levels.

The effect of dietary potassium and magnesium on calcium balance is shown in table 4. Fecal calcium excretion was ($P < .01$) increased as dietary magnesium levels increased at the low potassium level. High dietary potassium decreased ($P < .01$) fecal calcium. Calcium absorption, expressed as grams per day and as percent of intake, was depressed ($P < .01$) as dietary magnesium levels increased in the low potassium treatment levels. No effect of magnesium on calcium absorption was noted at the high potassium level. Calcium retention was lower ($P < .01$) for animals receiving low potassium.

The effect of dietary potassium and magnesium on phosphorus balance is shown in table 5. Fecal phosphorus increased ($P < .01$) as dietary magnesium increased in animals on the low potassium rations. High potassium decreased ($P < .001$) fecal phosphorus. Urinary phosphorus was decreased ($P < .001$) at the two higher dietary magnesium levels when both low and high potassium levels were fed. Apparent absorption of phosphorus, expressed as grams per day and as percent of intake, decreased at the two higher magnesium levels in both the low and high potassium levels. Absorption was ($P < .01$) higher in animals fed the highest level of potassium. Phosphorus retention was greater in animals fed the high potassium rations.

Potassium balance is presented in table 6. Fecal potassium was decreased ($P < .01$) as dietary magnesium levels increased in both the low and high potassium rations. Apparent absorption of potassium increased ($P < .05$) as dietary magnesium levels increased. Potassium retention was greater ($P < .001$) for animals on the high potassium treatment level.

Blood serum calcium, magnesium and inorganic phosphorus are presented in table 7. There were no significant differences in serum calcium or inorganic phosphorus, due to magnesium or potassium levels.

The apparent digestion coefficients for the eight rations are shown in table 8. Dry matter and crude fiber digestibility for the different rations were lower for the rations containing .63% magnesium than for the rations with lower magnesium levels. Means for ether extract digestibility were higher for the low potassium than for the high potassium rations. There were no differences in apparent digestibility of crude protein due to magnesium or potassium level.

TABLE 1. INGREDIENT AND CHEMICAL COMPOSITION OF BASAL RATION FED IN EXPERIMENT

Ingredient	Percent	Grams/day
Ground shelled corn	34.66	242.63
Ground corn cob fraction[a]	28.00	196.00
Corn gluten meal	11.54	80.70
Cellulose[b]	9.43	66.00
Cerelose[c]	7.00	49.00
Starch[d]	7.00	49.00
Defluorinated phosphate	1.19	8.33
Potassium bicarbonate	0.65	4.55
Magnesium oxide	0.03	0.21
Trace mineralized salt	0.50	3.50
Vitamins A and D[e]	+	+
Total	100.00	700.00
Chemical composition, %		
Dry matter	91.08	
Composition of dry matter		
Crude protein	11.76	
Crude fiber	25.50	
Ether extract	1.70	
Nitrogen-free extract	57.99	
Ash	3.41	
Calcium	0.41	
Magnesium	0.07	
Phosphorus	0.35	
Potassium	0.67	

[a]Number 4 cob fraction, The Andersons, Maumee, Ohio 43537.
[b]Solka floc, BW-20. Brown Co., Berlin N.H.
[c]A commercial preparation of glucose, Corn Products Refining Co., New York, NY.
[d]A commercial starch preparation, Corn Products Refining Co., New York, NY.
[e]Levels were 1890 I.U. vitamin A and 245 I.U. vitamin D per kilogram of ration.

TABLE 2. POTASSIUM AND MAGNESIUM LEVELS OF EXPERIMENTAL RATIONS

Potassium level	Magnesium level	Mineral elements			
		Potassium		Magnesium	
		g	%[a]	g	%[a]
Low	1	4.40	0.69	0.49	0.08
High	1	30.32	4.34	0.51	0.07
Low	2	4.60	0.72	1.10	0.17
High	2	33.76	4.82	1.11	0.16
Low	3	4.52	0.70	2.15	0.34
High	3	32.79	4.68	2.24	0.32
Low	4	4.40	0.69	4.10	0.63
High	4	34.35	4.82	4.13	0.58

[a]Dry basis.

TABLE 3. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM ON MAGNESIUM BALANCE. EXPERIMENT 2

Treatment level, %			Excretion				
Potassium	Magnesium	Intake	Fecal[a,b,c]	Urinary[a,b,c]	Apparent Absorption		Retention
		g/day	g/day	g/day	g/day[b]	% of intake	g/day
.7	.08	.49	.30	.22	.19	38.78	-.03
	.17	1.10	.53	.50	.57	52.13	.07
	.34	2.15	1.14	.95	.97	46.55	.06
	.63	4.10	2.46	1.23	1.64	39.00	.37
4.6	.07	.51	.43	.06	.08	16.01	.02
	.16	1.11	.77	.20	.34	30.51	.14
	.32	2.24	1.38	.41	.86	37.74	.45
	.58	4.13	2.77	.67	1.36	32.88	.69

[a]Values for the low-potassium ration were ($P < .01$) different than for the high-potassium rations.
[b]Values increased linearly ($P < .001$) as dietary magnesium levels increased.
[c]Magnesium X potassium interaction was significant ($P < .001$).

TABLE 4. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM ON CALCIUM BALANCE. EXPERIMENT 2.

Treatment level,[c] %			Excretion				
Potassium	Magnesium	Intake	Fecal	Urinary	Apparent Absorption		Retention
		g/day	g/day	g/day	g/day	% of intake	g/day
.7	.08	2.89	1.70[a]	.05	1.20[b]	41.31[a]	1.14[a]
	.17	2.95	1.88[a]	.04	1.07[b]	36.33[a]	1.03[a]
	.34	2.91	2.16[a]	.03	0.76[b]	25.80[a]	.72[a]
	.63	2.92	2.26[a]	.04	0.66[b]	22.60[a]	.62[a]
4.6	.07	2.77	1.59	.03	1.19	42.86	1.15
	.16	2.97	1.72	.03	1.25	42.23	1.22
	.32	2.82	1.64	.03	1.18	41.84	1.16
	.58	2.85	1.61	.04	1.24	42.61	1.20

[a]Values for high potassium level are lower ($P < .01$) than for the low potassium level.
[b]Values for the high potassium level are higher ($P < .01$) than for the low potassium level.
[c]Dry basis.

TABLE 5. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM ON PHOSPHORUS BALANCE. EXPERIMENT 2

Treatment level,[e] %			Excretion				
Potassium	Magnesium	Intake	Fecal[a,b]	Urinary[c]	Apparent Absorption[c,d]		Retention[d]
		g/day	g/day	g/day	g/day	% of intake	g/day
.7	.08	2.41	1.08	1.12	1.33	55.29	.21
	.17	2.47	1.14	1.06	1.33	53.50	.27
	.34	2.54	1.44	.78[c]	1.10	42.99	.32
	.63	2.49	1.80	.80[c]	.69	27.61	-.11
4.6	.07	2.46	.73	1.33	1.73	71.09[d]	.40
	.16	2.51	.68	1.27	1.83	72.77[d]	.56
	.32	2.50	.98	.79[c]	1.52	60.54[d]	.73
	.58	2.38	.88	.66[c]	1.50	63.12[d]	.84

[a]Values for the higher magnesium treatment level increased ($P < .01$).
[b]Values for high potassium were lower ($P < .01$).
[c]Values at the higher magnesium levels are lower ($P < .001$).
[d]Values for the higher potassium treatment levels are higher ($P < .01$).
[e]Dry basis.

TABLE 6. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM ON POTASSIUM BALANCE. EXPERIMENT 2

Treatment level[d], %			Excretion				
Potassium	Magnesium	Intake	Fecal[a]	Urinary	Apparent Absorption[b]		Retention[c]
		g/day	g/day	g/day	g/day	% of intake	g/day
.7	.08	4.39	.41	3.79	3.98	90.80	2.19
	.17	4.60	.30	4.40	4.30	93.45	-.10
	.34	4.52	.20	4.18	4.32	95.57	.14
	.63	4.39	.19	4.25	4.21	95.78	-.05
4.6	.07	30.32	.64	29.03	29.68	97.89	.65
	.16	33.76	.47	28.18	33.29	98.60	5.11
	.32	32.79	.33	27.47	32.46	99.00	4.99
	.58	34.35	.19	29.21	34.07	99.46	4.16

[a]Values for the higher magnesium levels were higher ($P < .01$).
[b]Values for the higher magnesium levels were higher ($P < .05$).
[c]Values for the high potassium were higher ($P < .001$).
[d]Dry basis.

TABLE 7. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM ON BLOOD SERUM, CALCIUM, MAGNESIUM AND INORGANIC PHOSPHORUS LEVELS. EXPERIMENT 2

Treatment level[c], %		Blood serum levels mg/100 ml.		
Potassium	Magnesium	Calcium	Magnesium[a,b]	Inorganic phosphorus
.7	.08	9.52	2.53	6.72
	.17	9.69	2.58	8.17
	.34	9.30	3.29	8.10
	.63	9.34	5.29	8.79
4.6	.07	9.44	2.44	9.03
	.16	9.25	2.73	7.09
	.32	9.85	2.87	8.85
	.58	9.82	3.52	7.73

[a]Values for the higher magnesium treatment levels were increased ($P < .001$).
[b]Values for the high potassium treatment levels were lower ($P < .001$).
[c]Dry basis.

TABLE 8. EFFECTS OF DIETARY POTASSIUM AND MAGNESIUM ON APPARENT DIGESTIBILITY

Treatment level,[c] %		Apparent coefficients of digestibility, %				
Potassium	Magnesium	Dry matter	Crude protein	Ether extract	Crude fiber	Nitrogen free extract
.7	.08	77.3	72.4	73.2	63.9	85.2
	.17	78.8	73.5	75.8	65.8	87.1
	.34	78.8	71.2	78.6	69.5	85.8
	.63	71.8[a]	69.9	70.9	52.1[a]	83.0
4.6	.07	81.8	75.5	65.4[b]	68.5	86.9
	.16	74.8	68.4	65.0[b]	54.4	82.7
	.32	77.4	69.7	71.1[b]	58.4	84.2
	.58	74.9[a]	69.6	68.3[b]	52.5[a]	83.3

[a]Values for the highest magnesium level were lower ($P < .05$) than for the other levels.
[b]Values for the high potassium level were lower ($P < .05$) than for lower level.
[c]Dry basis.

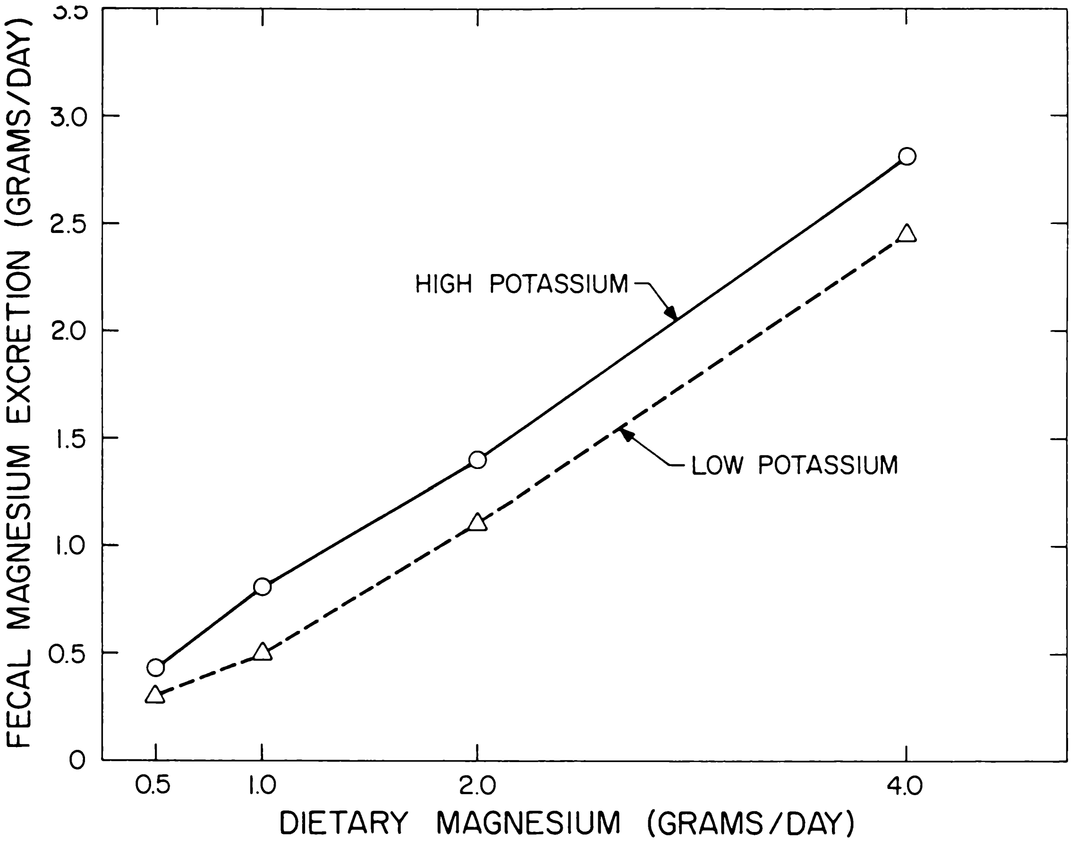

FIGURE I. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM LEVELS ON FECAL MAGNESIUM EXCRETION.

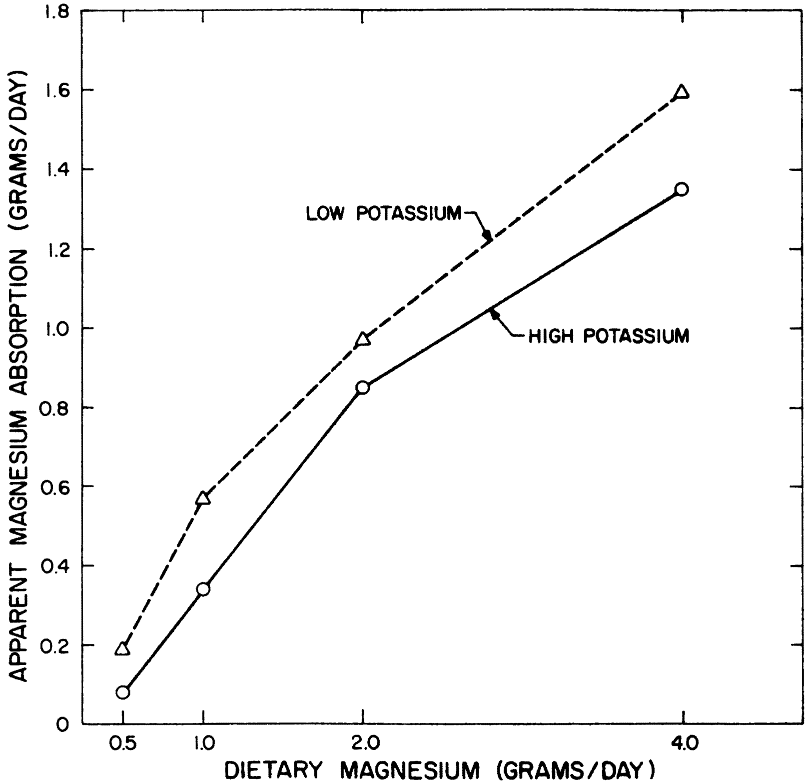

FIGURE 2. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM LEVELS ON APPARENT MAGNESIUM ABSORPTION.

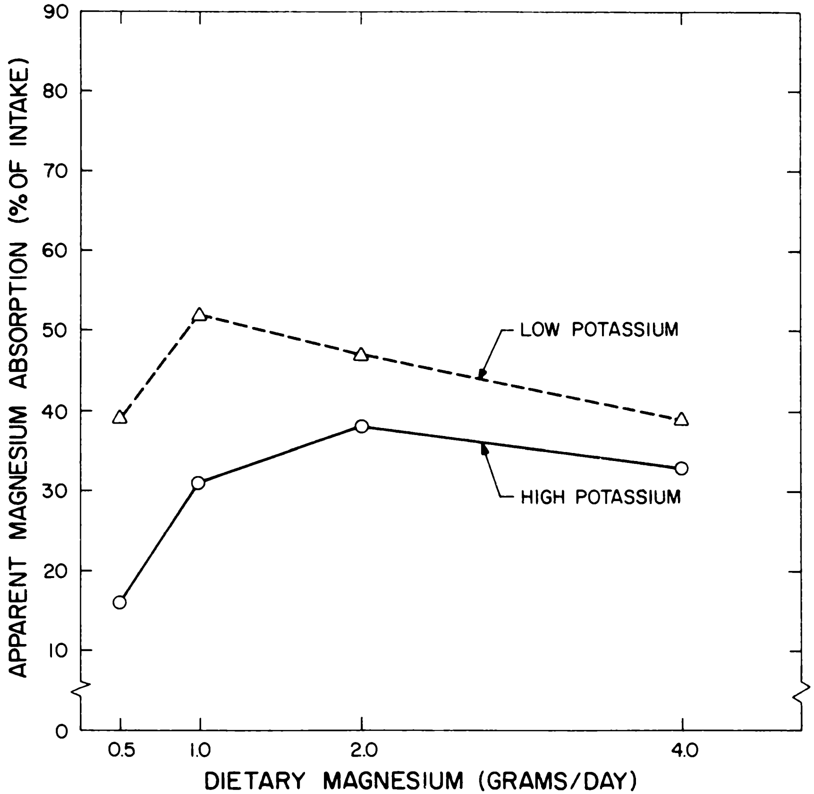

FIGURE 3. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM LEVELS ON APPARENT MAGNESIUM ABSORPTION.

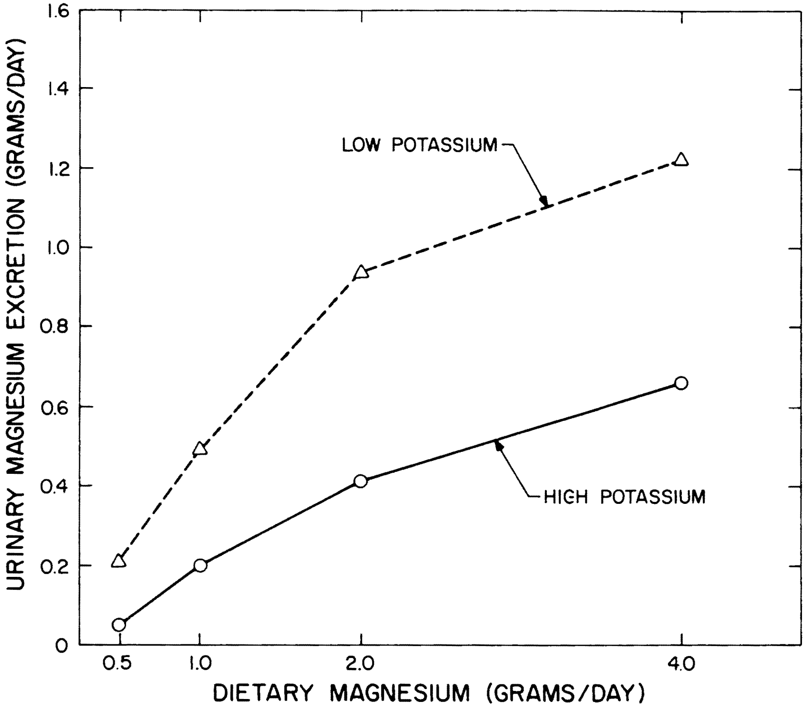

FIGURE 4. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM LEVELS ON URINARY MAGNESIUM EXCRETION.

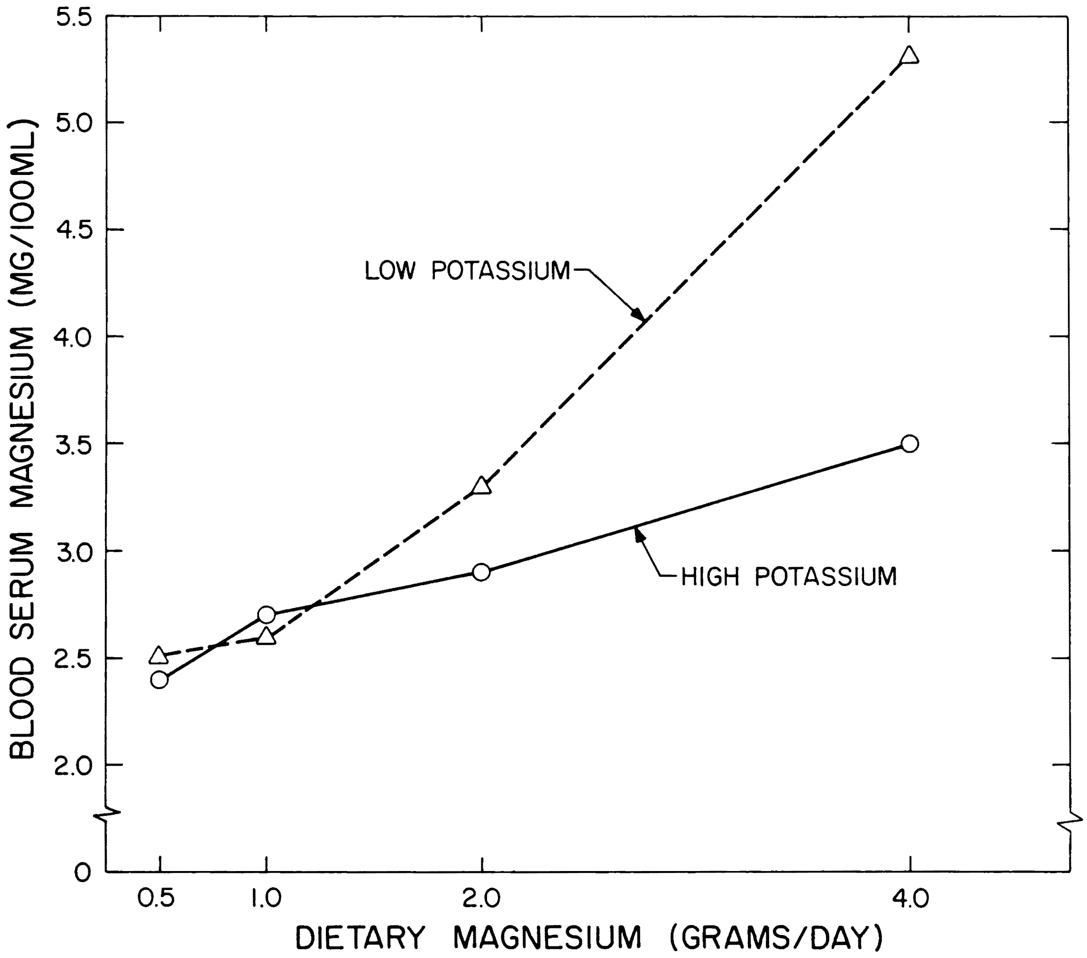

FIGURE 5. EFFECT OF DIETARY POTASSIUM AND MAGNESIUM LEVELS ON BLOOD SERUM MAGNESIUM.

FERMENTATION, UTILIZATION AND PALATABILITY OF BROILER LITTER ENSILED AT DIFFERENT MOISTURE LEVELS

L. F. Caswell, J. P. Fontenot and K. E. Webb, Jr.

In the 1973-74 Livestock Research Report (V.P.I. & S.U. Res. Div. Rep. 158) a laboratory study was reported in which broiler litter was ensiled at different moisture levels. The overall objective of that experiment was to obtain guidelines for ensiling studies on a larger scale. The data reported therein indicated that although fermentation was maximal in litter ensiled at 50% moisture, the physical characteristics of this material were such that it appeared that 40% moisture would be a more practical level at which to ensile the litter in the larger scale experiment.

The present experiments were conducted to study the fermentation characteristics of large masses of litter ensiled at 22 and 40% moisture and to assess the digestibility, nitrogen utilization and palatability of rations containing these ensiled materials.

Experimental Procedure

Wood shaving based broiler litter was obtained from one commercial broiler house. One group of broilers had been reared on the litter and had been fed monensin sodium and roxarsone. Samples of the litter were dried approximately 36 hr., and the moisture content thus determined was used to calculate the amount of water needed to prepare materials containing the desired moisture levels. Prior to ensiling, the litter was ground in a hammer-mill through a 1/4 in. mesh screen. One 1200 lb. batch of litter, containing 22.3% moisture (no water added), was thoroughly mixed in a horizontal mixer and augered into each of two silos. Two additional silos were filled with litter containing 40% moisture. Each of these silos contained the same amount of dry matter as the two silos described above. However, the procedure for mixing this litter, to which tap water was added, was slightly different. In an attempt to avoid mixing problems due to the sticky consistency of wet litter encountered in the previous laboratory study, only 600 lb. of litter were weighed into the mixer at one time instead of weighing in 1,200 lb., as was done for the first two silos filled. To this was slowly added a weighed quantity of tap water to increase the moisture content of the litter from 22.3% to 40%.

Each silo consisted of a plywood box with cubic dimensions of 4 ft. lined with two polyethylene bags. After filling, a thermistor probe was inserted into the ensiled mass to a depth of 1 ft. and both polyethylene bags were individually twisted and sealed around the thermistor probe lead. An attempt was made to expel as much of the air above the ensiled mass as possible before sealing the bags. Silo temperature measurements were made daily.

One 22% moisture silo and one 40% moisture silo were opened after 159 days. The litters from these silos were fed concurrently in a metabolism trial with sheep and in the first of two palatability trials with cattle. The remaining two silos were opened for feeding at the beginning of the second palatability trial, 212 days after ensiling.

Each silo was sampled daily at feeding, and the samples periodically were composited according to type of ensiled material and frozen for subsequent chemical analyses. Samples for microbiological determinations were obtained from each silo upon opening and on the last day of feeding from that silo.

Samples of the initial and ensiled litters were analyzed for dry matter, crude fiber, ether extract, ash, NFE, total nitrogen (crude protein), protein nitrogen, non-protein nitrogen, uric acid nitrogen, ammonia nitrogen, arsenic (as a measure of roxarsone) and monensin sodium. Total bacteria and coliform counts and qualitative tests for salmonella, shigella and proteus were conducted. Water extracts of the initial and ensiled litters were subjected to pH measurement and analyzed for water soluble carbohydrates, lactic acid and volatile fatty acids.

A metabolism trial was conducted with 24 crossbred wethers averaging 80 lb. initially. The composition of the rations used in the experiment is presented in table 1. The following four supplements supplied 50% of the dietary crude protein for the four respective rations: 1) dry heat processed litter; 2) 22% moisture ensiled litter; 3) 40% moisture ensiled litter and 4) soybean meal. Levels of ingredients were varied in an attempt to equalize crude protein and TDN among rations. Vitamins A and D were supplemented in the rations at levels to supply 770 IU and 200 IU per animal per day, respectively. The dry heat processed litter consisted of the portion of litter remaining after filling the silos. It was ground in a hammermill through a 1/4 in. mesh screen and dry heat processed in a forced-draft oven at 500^{o}F for 30 min. with the litter at a depth of 1/2 in. Nitrogen loss as a result of processing was approximately 25%. The shelled corn and corn cobs used in the rations were ground through a 1/4 in. mesh screen.

In an attempt to equalize dry matter intake, the sheep were fed 800, 822, 860 and 806 g of the processed litter, 22% moisture litter silage, 40% moisture litter silage and soybean meal rations, respectively, plus 10 g of trace mineralized salt per day in two equal feedings (8:00 a.m. and 8:00 p.m.). Water was available *ad libitum* except during the 2-hour feeding periods.

The trial consisted of a 10-day preliminary period followed by a 10-day collection period during which total feces and urine were collected. At the end of the collection period, samples of rumen contents were taken with a stomach tube 2 hr. after the morning feeding. Rumen contents were strained and pH of the strained fluid was determined electrometrically. Analyses for ammonia nitrogen and volatile fatty acids were performed on the strained fluid. Jugular blood samples were taken on the same day 6 hr. after the morning feeding and were analyzed for blood urea.

The palatability of the litter silages was evaluated in two trials with 12 Shorthorn, Hereford and Angus yearling steers averaging 740 lb. bodyweight. Each trial consisted of a 10-day adjustment period followed by a 15-day intake measurement period. The compositions of the experimental rations are shown in table 2. The four rations contained the same major ingredients as those used in the metabolism trial described above. Calculated TDN was equal among rations. For the three litter-containing rations, litter contributed 50% to the total ration dry matter. The shelled corn and corn cobs were ground through a 1/2 in. mesh screen. Trace mineralized salt was provided in block form while the steers were confined to individual stalls. An intramuscular injection of 2,000,000 IU of vitamin A was given to each animal prior to trial 1.

The cattle were fed the respective rations once daily while confined to individual stalls for a period of 16 hr. (3:00 p.m. to 7:00 a.m.). They were kept as a group in an exercise lot the remainder of the time. Water was available only in the exercise lot. An attempt was made to feed approximately 5 to 10% in excess of consumption. During the intake measurement period, the daily refusal from each animal was sampled and stored in individual polyethylene bags below freezing. At the end of each trial these samples were composited by animal and used for dry matter determination. While in the stalls, eating patterns of the individual steers were measured during the last 15 days of each trial using photoelectric relays and operation recorder.

Results

In table 3 is shown the composition of litter ensiled in this study. This litter was typical of most litter obtained from commercial broiler operations in Virginia.

The ensiling process did not appear to appreciably affect the temperature of the silages. Ambient temperature was generally reflected in the daily temperature of the silages. Upon opening the silos, the aroma of the 40% moisture silage was quite pleasing and indicative of fermentation. No surface or subsurface mold was observed. The odor of the 22% moisture silage was not noticeably different from that on the day of ensiling. Table 4 contains the chemical composition of the initial and ensiled materials. Proximate constituents were essentially unchanged as a result of fermentation.

Fermentation characteristics of both the initial mixtures and silages are presented in table 5. The marked drop in pH of litter ensiled at 40% moisture was indicative of active fermentation in this material. Elevation of pH as a result of ensiling litter at 22% moisture may possibly have been due to liberation of ammonia from the hydrolysis of uric acid during the fermentation period. Production of lactic and acetic acids was higher ($P<.01$) in the 40% than in the 22% moisture silage. In the 22% moisture material, disappearance of water soluble carbohydrates was negligible, whereas the value for the 40% moisture silage indicated that considerable fermentation of sugars had taken place.

In table 6 are shown the levels of nitrogen components of the initial mixtures and silages. Total nitrogen and all nitrogen component levels in the initial materials did not vary significantly between moisture levels. In the silages, only uric acid differed significantly ($P<.01$) between moisture levels. Possibly, this was the result of a shift in nitrogen from uric acid toward ammonia for the 40% silage since uric acid nitrogen was lower and ammonia nitrogen was higher in the 40% moisture silage than in the 22% moisture initial mixture.

The bacteria counts of the initial mixtures and silages are presented in table 7. In the silages, total bacteria and coliform counts were reduced to 625 million and 24 organisms per gram of wet litter respectively, for the material containing 22% moisture, even though fermentation did not take place in this litter to any measurable extent. Coliforms were eliminated in litter ensiled at 40% moisture. All initial mixtures and silages were free of salmonella, shigella and proteus organisms.

In table 8 are shown the levels of arsenic and monensin sodium residues in the initial mixtures and silages. Arsenic levels were unaffected by ensiling at either moisture level, and no detectable levels of monensin sodium were found in the initial mixtures or silages.

Nitrogen utilization data are presented in table 9. Regardless of the manner in which expressed, nitrogen retention was lower ($P<.01$) for the dry heat processed litter rations than for the other three rations. Retention by the wethers fed the litter silages was not significantly different from that of the wethers fed soybean meal as the source of supplemental protein.

The apparent digestibility data are also presented in table 9. Treatment did not significantly affect the apparent digestibility of crude protein or NFE. The apparent digestibility coefficient for crude fiber in the ration containing soybean meal was lower ($P<.01$) than values for the three litter rations. This depression in crude fiber digestibility appeared to have resulted in lower ($P<.05$) dry matter digestibility for the soybean meal supplemented ration than for the others.

In table 10 are shown the ruminal fluid pH and ammonia nitrogen and blood urea of the wethers fed the four rations. Ruminal fluid pH values were quite similar among rations. No significant differences were found. The ruminal fluid ammonia nitrogen values of 26.2 and 26.0 mg/100 ml for the sheep fed the processed litter and 40% moisture litter silage rations, respectively, were higher ($P<.01$) than the value of 14.2 mg/100 ml for the soybean meal ration. Blood urea levels followed the same general trend as ruminal fluid ammonia nitrogen levels, were within the normal range and were not significantly different among treatments.

Ruminal fluid volatile fatty acid concentrations of the four groups of wethers are shown in table 11. When expressed as μ moles/ml, propionic was higher ($P<.05$) for lambs fed the 22% moisture silage than for the other three groups.

Dry matter intake data for the four groups of cattle indicated that both rations containing litter silages were not as readily accepted by the steers as the ration containing soybean meal. Although data available on the palatability of litter silage is limited, satisfactory consumption of litter silage containing 35 to 38% moisture has been reported by other researchers when the material was fed to heifer calves. Perhaps in the present study, the adjustment period and the intake measurement period were too short to allow the animals time to adapt to the ration containing 40% moisture litter silage. Previous research at this station has shown that cattle will adjust to rations containing 25 or 50% broiler litter over extended periods of feeding.

During the first 6 hr. that the steers were confined to individual stalls daily, the number of minutes per hour spent eating the rations generally followed the same trend as dry matter intake. No significant differences were observed among eating pattern measurements for the last 10 hr. of confinement.

Data collected in this study indicate that active fermentation will occur in litter ensiled at a moisture level of 40%. Furthermore, utilization of nitrogen from a ration supplemented with 40% moisture litter silage was comparable to that of a conventional ration supplemented with soybean meal when fed to sheep. Although intake by cattle of a ration containing 40% moisture litter silage was not satisfactory, this response may have been partially due to the short period of time over which the product was fed. A longer feeding trial is presently being conducted with cattle in an attempt to more accurately evaluate the palatability of litter silage containing 40% moisture and to elucidate the cause of depressed intake observed in the study reported herein.

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS FED IN METABOLISM TRIAL

Item	Nitrogen supplements: Processed litter	Litter silage, 22% moisture	Litter silage, 40% moisture	Soybean meal
Ingredient composition, %				
Ground corn cobs	34.6	37.1	35.4	43.2
Ground corn grain	48.9	46.4	44.3	45.6
Processed litter	16.5	----	----	----
Litter silage, 22% moisture	----	14.4	----	----
Litter silage, 40% moisture	----	----	18.4	----
Soybean meal[a]	----	----	----	10.3
Corn sugar[b]	----	2.1	1.9	0.5
Limestone	----	----	----	0.4
Vitamins A[c] & D[d]	++	++	++	++
Chemical composition				
Dry matter, %	91.8	89.7	86.0	91.8
Composition of dry matter, %				
Crude protein	10.3	10.4	10.9	10.4
Ether extract	2.2	2.1	2.3	1.8
Crude fiber	19.5	20.3	20.2	20.9
Ash	3.9	3.5	3.6	2.5
NFE	64.1	63.7	63.0	64.4

[a]Solvent processed, 44% crude protein guaranteed.
[b]Cerelose, Corn Products Refining Co., New York, N.Y.
[c]Fed to supply 770 IU per animal daily.
[d]Fed to supply 200 IU per animal daily.

TABLE 2. COMPOSITION OF EXPERIMENTAL RATIONS FED IN PALATABILITY TRIALS

Item	Nitrogen supplements: Processed litter	Litter silage, 22% moisture	Litter silage, 40% moisture	Soybean meal
Ingredient composition, %				
Ground corn cobs	10.2	9.2	7.8	39.2
Ground corn grain	40.6	36.9	31.3	41.0
Processed litter	49.2	---	---	---
Litter silage, 22% moisture	---	53.9	---	---
Litter silage, 40% moisture	---	---	60.9	---
Soybean meal[a]	---	---	---	19.2
Limestone	---	---	---	0.6
Chemical composition				
Dry matter, %	90.6	84.5	71.9	90.9
Composition of dry matter, %				
Crude protein	18.9	24.0	24.5	14.3
Ether extract	2.9	2.6	2.8	2.0
Crude fiber	16.9	17.2	17.3	20.7
Ash	7.7	8.2	8.2	3.5
NFE	53.6	48.0	47.2	59.5

[a]Solvent processed, 44% crude protein guaranteed.

TABLE 3. COMPOSITION OF BROILER LITTER[a]

Item	Broiler litter
Dry matter, %	77.7
Composition of dry matter, %	
Crude protein	40.0
Ether extract	2.4
Crude fiber	19.2
Ash	13.8
NFE	24.7
Water-soluble carbohydrates	3.6
Total nitrogen	6.4
Composition of total nitrogen, %	
Protein nitrogen	43.0
Non-protein nitrogen	57.0
Uric acid nitrogen	34.6
Ammonia nitrogen	15.0

[a]Values represent an average of four samples of litter.

TABLE 4. COMPOSITION OF INITIAL MIXTURES AND SILAGES

Type of material	Estimated moisture	Dry matter	Composition of dry matter: Crude protein	Ether extract	Crude fiber	Ash	NFE
	%	%	%	%	%	%	%
Initial mixtures	22	77.9[a]	39.0	2.18	19.6	13.6	25.6
	40	60.2[b]	40.6	2.50	18.9	14.0	24.0
Silages	22	80.1[c]	39.2	2.09[c]	21.7	14.1	22.9
	40	60.4[d]	39.8	2.46[d]	20.6	14.4	22.7

[a,b]Means for initial mixtures having different superscripts are significantly ($P<.01$) different.

[c,d]Means for silages having different superscripts are significantly ($P<.01$) different.

TABLE 5. FERMENTATION CHARACTERISTICS OF INITIAL MIXTURES AND SILAGES

Type of material	Estimated moisture	pH	Level, % of dry matter		
			Lactic acid	Acetic acid	Water-soluble carbohydrates
	%				
Initial mixtures	22	7.64	0	0	3.55
	40	7.61	0	0	3.72
Silages	22	8.18[a]	0.13[a]	0[a]	3.48[a]
	40	5.72[b]	2.83[b]	2.08[b]	2.95[b]

[a,b]Means for silages having different superscripts are significantly ($P<.01$) different.

TABLE 6. NITROGEN COMPONENTS OF INITIAL MIXTURES AND SILAGES

Type of material	Estimated moisture	Total nitrogen	Composition of total nitrogen: Protein nitrogen	Non-protein nitrogen	Uric acid nitrogen	Ammonia nitrogen
	%	% of DM	%	%	%	%
Initial mixtures	22	6.25	43.5	56.5	34.4	15.7
	40	6.50	42.8	57.2	37.8	20.2
Silages	22	6.27	48.9	51.1	32.4[a]	17.8
	40	6.36	48.6	51.4	38.4[b]	19.5

[a,b]Means for silages having different superscripts are significantly (P<.01) different.

TABLE 7. BACTERIA COUNTS OF INITIAL MIXTURES AND SILAGES

Type of material	Estimated moisture	Total bacteria	Coliforms	Salmonella	Shigella	Proteus
	%	10^9 per gram	10^3 per gram			
Initial mixtures	22	3.68	1,109	-	-	-
	40	5.83	815	-	-	-
Silages	22	0.625[a]	0.024[c]	-	-	-
	40	0.039[b]	0[d]	-	-	-

[a,b]Means for silages having different superscripts are significantly ($P<.05$) different.

[c,d]Means for silages having different superscripts are significantly ($P<.01$) different.

TABLE 8. ARSENIC AND MONENSIN SODIUM RESIDUES IN INITIAL MIXTURES[a]

Type of material	Estimated moisture	Concentration, dry basis	
		Arsenic	Monensin sodium
	%	ppm	ppm
Initial mixtures	22	6.2	0
	40	4.7	0
Silages	22	6.2	0
	40	4.8	0

[a]Analysis performed on two composited samples represented all initial mixture samples of each moisture level and on two composited samples representing all silage samples of each moisture level.

TABLE 9. NITROGEN UTILIZATION AND APPARENT DIGESTIBILITY BY SHEEP

Item	Nitrogen supplements			
	Heat processed litter	Litter silage, 22% moisture	Litter silage, 40% moisture	Soybean meal
Nitrogen utilization				
Nitrogen intake, g/day	12.04	12.20	12.87	12.34
Nitrogen excretion, g/day				
Fecal	4.40	4.47	4.47	4.55
Urinary	7.15^{a}	6.23^{a,b}	6.74^{a,b}	5.79^{b}
Total	11.55^{a}	10.70^{a,b}	11.21^{a}	10.34^{b}
Nitrogen retention				
Grams per day	0.49^{a}	1.49^{b}	1.66^{b}	2.01^{b}
Percent of intake	4.1^{a}	12.2^{b}	12.9^{b}	16.3^{b}
Percent of absorbed	6.5^{a}	19.5^{b}	19.9^{b}	25.6^{b}
Apparent digestibility, %				
Dry matter	74.3^{c}	73.9^{c}	74.3^{c}	69.9^{c}
Crude protein	63.5	63.3	65.3	63 2
Ether extract	68.6^{c,d}	69.5^{d}	71.4^{d}	64.2^{c}
Crude fiber	64.2^{a}	64.0^{a}	63.8^{a}	54.8^{b}
NFE	80.5	79.8	80.1	76.8

[a,b] Means having different superscripts are significantly ($P<.01$) different.

[c,d] Means having different superscripts are significantly ($P<.05$) different.

TABLE 10. RUMINAL FLUID pH AND AMMONIA NITROGEN AND BLOOD UREA OF SHEEP

Item	Nitrogen supplements			
	Processed litter	Litter silage, 22% moisture	Litter silage, 40% moisture	Soybean meal
Ruminal fluid				
pH	6.21	6.18	6.40	6.30
NH_3-N, mg/100 ml	26.2[a]	18.4[a,b]	26.0[a]	14.2[b]
Blood urea, mg/100 ml	19.5	16.3	19.3	16.1

[a,b]Means having different superscripts are significantly (P<.01) different.

TABLE 11. RUMINAL FLUID VOLATILE FATTY ACID CONCENTRATIONS OF SHEEP

Item	Nitrogen supplements			
	Processed litter	Litter silage, 22% moisture	Litter silage, 40% moisture	Soybean meal
Volatile fatty acids, μ moles/ml				
Acetic	50.7	50.7	49.0	50.2
Propionic	19.4^{a}	25.1^{b}	18.9^{a}	19.5^{a}
Butyric	8.7	7.6	8.4	8.7
Valeric	1.0	1.0	0.9	1.1
Isobutyric	1.4	1.4	1.1	1.7
Isovaleric	2.1^{a}	1.1^{b}	1.6^{a,b}	1.5^{a,b}
Total	83.2	86.9	79.9	82.7
Volatile fatty acids, moles/100 moles				
Acetic	60.9	58.3	61.5	60.8
Propionic	23.3	28.9	23.6	23.5
Butyric	10.4	8.8	10.5	10.5
Valeric	1.2	1.3	1.1	1.4
Isobutyric	1.7	1.6	1.4	2.1
Isovaleric	2.6^{a}	1.2^{c}	2.0^{a,b}	1.8$^{b.c}$

^{a,b,c}Means having different superscripts are significantly (P<.05) different.

MAGNESIUM SUPPLEMENTATION OF BEEF COWS ON PASTURE WITH MIXTURES CONTAINING DIFFERENT LEVELS OF COTTONSEED MEAL[1]

T. M. Frye, J. P. Fontenot and K. E. Webb, Jr.

Magnesium oxide is one of the most nutritionally available forms of magnesium for supplementing ruminants. However, magnesium oxide is not palatable when fed alone as an ad-libitum magnesium supplement. The formulation of palatable magnesium oxide mixtures for supplementing beef cows on pasture has been approached at this Station, using a variety of common feedstuffs. The feedstuffs used have included trace mineralized salt, steamed bonemeal, dry molasses, soybean meal, ground corn grain, dehydrated alfalfa meal, corn distillers dried grain and cottonseed meal. The amount of these feedstuffs needed for obtaining optimum intake deserves special consideration for economical reasons. Magnesium requirement has been previously reported to be approximately .35 and .70 oz. per head per day for gestating and lactating beef cows respectively. Intakes of .53 to .88 ounces of magnesium per head have been obtained with a mixture of trace mineralized salt, magnesium oxide and cottonseed meal in a 1:1:1 ratio.

The present experiment was conducted to determine magnesium intake from mixtures containing a constant level of magnesium oxide and varied levels of trace mineralized salt and cottonseed meal.

Experimental Procedure

Five Angus and 3 Shorthorn cows averaging 8 years of age with nursing calves averaging 33 days of age were blocked by age, weight and calf age and allotted to two 4 X 4 randomly selected Latin squares. Each of the eight cows grazed a pasture plot of 0.75 acre. The pasture herbage was predominantly orchardgrass, white clover and blue grass. The experiment was conducted for 60 days covering the period of May 22 to July 22, 1974. This was divided into four successive 15-day trials. During the 4 trials each of the four cows in each Latin square received one of the following test supplemental magnesium oxide mixtures: 1) Trace mineralized salt - 67%, magnesium oxide - 33% and cottonseed meal - 0%; 2) Trace mineralized salt - 52%, magnesium oxide - 33% and cottonseed meal - 15%; 3) Trace mineralized salt - 42%, magnesium oxide - 33% and cottonseed meal - 25%; 4) Trace mineralized salt - 34%, magnesium oxide - 33% and cottonseed meal - 33%. The test mixtures were offered to the experimental cows ad libitum in covered mineral boxes constructed to limit mineral feeding to the cows only. Consumption of the mixtures was measured by collecting and

[1]Magnesium oxide was supplied by Gelkin Associates, Norristown, Pa.

weighing the refused amount at the end of the last two 5-day periods of the four trials.

Results and Discussion

Mean consumption values of the total mixture, magnesium oxide and magnesium per head per day are shown in table 1. The cows consistently consumed more of the mixture containing trace mineralized salt, magnesium oxide and cottonseed meal in a 1:1:1 ratio. This mixture was consumed at the rate of 3.4 oz./head/day. The mixture containing 42% trace mineralized salt and 25% cottonseed meal was consumed at the second highest level (2.0 ox./head/day). The mixtures containing 0 and 15% cottonseed meal were consumed at approximately equal levels (1.5 oz./day). Magnesium consumption based on the magnesium oxide consumed was .28, .27, .37 and .61 oz./head/day for mixtures containing 0, 15, 25 and 33% cottonseed meal, respectively.

Based on these data, it appears that during lactation when the requirement is high, a mixture similar to the mixture containing 33% cottonseed meal is necessary.

TABLE 1. MEAN CONSUMPTION OF SUPPLEMENTAL MAGNESIUM OXIDE MIXTURES BY BEEF COWS[a]

Item	Percentages of trace mineralized salt and cottonseed meal[b]			
	67:0	52:15	42:25	34:33
	oz./head/day			
Mixture	1.54	1.49	2.06	3.42
Magnesium oxide	.51	.50	.69	1.13
Magnesium[c]	.28	.27	.37	.61

[a]Mean consumption values are for 4 periods, 10 days each period.
[b]Each mixture contained 33% magnesium oxide.
[c]From feed grade magnesium oxide.

DIGESTIBILITY OF UNTREATED AND SODIUM HYDROXIDE TREATED STEER FECAL WASTE

D. M. Lucas, J. P. Fontenot and K. E. Webb, Jr.

Recently, considerable attention has been focused on developing new methods of animal waste disposal. Refeeding, particularly to ruminants, is one method which offers a means of alleviating the animal waste problem, as well as a method of recovering some of the potentially valuable nutrients contained in these materials.

In a previous study with steers, dry matter digestibility of fecal waste collected from steers fed a 50% roughage ration and oven dried at 248° F was only 16.6%. Results of preliminary *in vitro* studies indicate that fecal dry matter from high concentrate fed steers may be considerably more digestible than that from steers fed a 50% roughage ration. Furthermore, there is evidence that chemical treatment of cattle fecal waste may improve digestibility.

A study was conducted to determine chemical composition and digestibility of untreated and chemically treated heat-dried fecal waste from steers fed rations containing either 50% or 10% roughage.

Experimental Procedure

Six yearling steers averaging 660 lb. initially were used in two total collection digestion trials. A switch-back design was used with three steers receiving a 50% roughage ration and three steers receiving a 10% roughage ration in each trial. Rations were composed of shelled corn, grass hay, soybean meal, molasses, limestone and trace mineralized salt (table 1). Rations were supplemented with vitamins A and D. Both rations were ground in a hammermill through a 1 in. screen, and mixed in a vertical mixer. All steers were fed 5.5 lb. of their respective ration twice daily at 7:00 a.m. and 5:00 p.m. (11.0 lb./day). Steers had access to water at all times, except during the 1 hr. feeding periods.

Each trial consisted of a 10-day preliminary period followed by a 14-day collection period during which feces and urine were collected and sampled daily. The remainder of the feces was processed daily. On days 1, 3, 5, 7, 9, 11 and 13 of each collection period, untreated feces were placed in screen wire trays and dried in a forced draft oven at 248° F for 24 hr. On days 2, 4, 6, 8, 10, 12 and 14 of each collection period, the feces were treated by adding 3% sodium hydroxide, by weight, and dried as previously described. Sodium hydroxide treated feces were prepared for drying by mixing dry sodium hydroxide flakes with wet feces by hand. Processed fecal waste for each treatment was coarsely ground and stored for subsequent refeeding to sheep.

Steer fecal waste collected and processed during the two digestion trials was fed to sheep in a metabolism trial utilizing 30 wether lambs (avg. initial wt., 77 lb.). A randomized block design was used with 6 lambs receiving each of five treatments: 1) basal, 2) 75% basal and 25% untreated low roughage fecal waste, 3) 75% basal and 25% sodium hydroxide treated low roughage fecal waste, 4) 75% basal and 25% untreated high roughage fecal waste, 5) 75% basal and 25% sodium hydroxide treated high roughage fecal waste. The basal ration contained 30% roughage. Ingredient and chemical composition of the rations fed is presented in table 2.

The basal ration was ground in a hammermill through a 1/2 in. screen and mixed in a vertical mixer. Rations containing dried steer fecal waste were prepared by substituting the four types of dried fecal waste for 25% (as fed) of the basal ration and mixing by hand just prior to feeding. The metabolism trial consisted of a 10-day preliminary period, followed by a 10-day collection period during which total fecal and urinary collections were made. The feces were dried daily in a forced draft oven at a maximum temperature of 140° F and the dried feces were composited for 10 days. The urine was collected in dilute acid, and diluted with water to a constant weight daily prior to sampling. Grab samples of the basal ration and the four types of fecal waste were taken at each feeding for 10 days starting 2 days before the beginning of the collection period, and stored in respective sealed jars.

Results

Apparent digestion coefficients for the rations fed to steers producing fecal waste for refeeding (table 1) were dry matter, 78.3 and 67.0%; crude protein, 66.4 and 53.3%; crude fiber, 50.6 and 60.3% for the 10% and 50% roughage rations, respectively.

The chemical composition of the four types of fecal waste collected and processed in the steer trials and fed to sheep at a level of 25% of the ration (as fed) is presented in table 3. Crude protein content was 20.69, 17.03, 18.04, and 14.89%, dry basis, for oven-dried untreated low roughage, treated low roughage, untreated high roughage and treated high roughage fecal waste, respectively. Apparently, there was some loss of nitrogen as a result of treating wet fecal waste with 3% sodium hydroxide. A similar reduction in crude protein content of sodium hydroxide treated fecal waste occurred for waste from steers fed the high and low roughage rations. Crude fiber content of fecal waste from steers fed a low roughage ration was less than that for fecal waste from steers fed a high roughage ration, and crude fiber content of the fecal waste was reduced by treating with the alkali.

Apparent digestibility values for the basal and fecal waste containing rations fed to sheep are presented in table 4. Apparent dry matter digestibility was decreased by substitution of all types of fecal waste for 25% of the basal ration. However, the decrease resulting from substitution of 25% untreated high roughage feces was much greater than that resulting from substitution of the untreated low roughage feces. Treating the waste with alkali improved dry matter digestibility of the ration, especially for the ration containing high roughage waste. Apparent digestibility of ration crude protein, crude fiber and ether extract was also decreased by substitution of 25% untreated fecal waste. Crude fiber digestibility was improved, but apparent digestibility of crude protein was lower for the rations containing treated waste, compared to untreated waste.

Values for apparent digestibility of the four types of fecal waste, calculated by difference, are presented in table 5. Apparent dry matter digestibilities of 52.90, 66.97, 24.29 and 52.92% were calculated for untreated low roughage, treated low roughage, untreated high roughage and treated high roughage fecal waste, respectively. The value of 24.29% for untreated high roughage waste dry matter when fed to sheep is somewhat higher than the value of 16.55% determined for similar material when fed to steers in a previous study. However, both values are quite low. Treating the high roughage waste with 3% sodium hydroxide increased dry matter digestibility by 118% (24.3 vs. 52.9%). Although the difference was not as large, treating the low roughage waste also improved digestibility (52.9 vs. 67.0%). Apparent digestibility of crude protein in the untreated low roughage waste was 49.09%, considerably higher than that for the other types of waste studied.

TABLE 1. COMPOSITION OF STEER RATIONS

Item	Ration: High roughage	Ration: Low roughage
Ingredient composition, %		
Shelled corn	40.2	73.8
Grass hay	50.0	10.0
Soybean meal	4.0	10.0
Molasses	5.0	5.0
Limestone	0.3	0.7
Trace mineralized salt	0.5	0.5
Vitamins[a] A and D	++	++
Chemical composition		
Dry matter, %	90.0	89.7
Composition of dry matter, %		
Crude protein	13.4	13.6
Ether extract	3.0	4.0
Crude fiber	19.6	6.7

[a]Supplied 4,000 I.U. vitamin A and 600 I.U. vitamin D per kilogram of ration.

TABLE 2. COMPOSITION OF SHEEP RATIONS

Item	Basal	Low roughage waste[a] Untreated	Low roughage waste[a] Treated	High roughage waste[a] Untreated	High roughage waste[a] Treated
Ingredient compositon, %					
Shelled corn	62.00	46.50	46.50	46.50	46.50
Grass hay	30.00	22.50	22.50	22.50	22.50
Soybean meal	2.00	1.50	1.50	1.50	1.50
Steer feces	---	25.00	25.00	25.00	25.00
Molasses	5.00	3.75	3.75	3.75	3.75
Limestone	0.50	0.37	0.37	0.37	0.37
Trace mineralized salt	0.50	0.38	0.38	0.38	0.38
Vitamins[b] A and D	++	++	++	++	++
Chemical composition					
Dry matter, %	89.20	90.80	90.52	90.47	90.05
Composition of dry matter, %					
Crude protein	11.73	14.09	13.11	13.38	12.54
Ether extract	3.68	3.94	3.11	3.39	3.14
Crude fiber	11.98	12.96	12.10	14.19	13.49

[a]Rations were composed of 75% basal and 25% waste.

[b]Supplied 1333 IU Vitamin A and 400 IU Vitamin D per kilogram of basal ration.

TABLE 3. CHEMICAL COMPOSITION OF DRIED STEER FECAL WASTE

	Dried steer fecal waste			
	Low roughage waste		High roughage waste	
	Untreated	Treated	Untreated	Treated
Chemical composition				
Dry matter, %	95.58	94.50	94.28	92.63
Composition of dry matter, %				
Crude protein	20.69	17.03	18.04	14.89
Ether extract	4.69	1.51	2.56	1.58
Crude fiber	15.72	12.44	20.46	17.84

TABLE 4. APPARENT DIGESTIBILITY OF BASAL AND STEER FECAL WASTE CONTAINING RATIONS BY SHEEP

		Ration			
		Low roughage waste		High roughage waste	
Item	Basal	Untreated	Treated	Untreated	Treated
No. of animals	6	6	6	6	6
Apparent digestibility, %					
Dry matter	76.57	70.34	74.06	62.95	70.49
Crude protein	60.42	56.04	49.78	50.46	48.31
Crude fiber	55.81	48.40	59.97	36.03	51.46
Ether extract	84.70	82.39	81.52	79.01	80.95

TABLE 5. APPARENT DIGESTIBILITY OF DRIED TREATED AND UNTREATED STEER FECAL WASTE

Item	Dried steer feces			
	Low roughage waste		High roughage waste	
	Untreated	Treated	Untreated	Treated
Apparent digestibility,[a] %				
Dry matter	52.90	66.97	24.29	52.92
Crude protein	49.09	29.07	32.07	20.76
Crude fiber	32.57	60.14	3.17	43.02
Ether extract	77.31	59.56	55.79	55.66

[a]Calculated by difference by the method of Crampton and Harris (1969).

PROTEIN QUALITY OF RUMEN BACTERIAL PREPARATIONS FROM CATTLE FED RATIONS OF DIFFERENT ROUGHAGE CONTENT

R. B. Keyser, K. E. Webb, Jr. and J. P. Fontenot

Ruminants are known to convert part of the dietary protein and nitrogen into microbial protein in the rumen. Both bacteria and protozoa are presented to the abomasum and small intestine for further digestion and absorption. Rumen bacterial populations differ as a result of varying dietary ratios of roughage and concentrate. In this study, an attempt was made to determine the protein quality of rumen bacteria from steers fed rations differing in roughage to concentrate ratio.

Experimental Procedure

Rumen fluid was collected from two steers fed an 84% concentrate ration and two steers fed a 79% roughage ration *via* rumen cannulae. Feed particles and protozoa were removed from the fluid by centrifuging at 1,000 x g and bacteria were harvested from the supernate by centrifuging at 27,000 x g in a continuous flow system. The bacteria were frozen, lyophilized and ground. The bacteria were analyzed for amino acid composition and for total nitrogen content.

Seventy-five Sprague-Dawley, male, weanling rats were fed a standard diet for 5 days. They were then placed into 15 blocks of 5 rats each based on weight and gain during the 5-day period. Rats within each block were then allotted to five groups. One group was fasted for 24 hours, then sacrificed. The remaining four groups were placed in metabolism cages and fed *ad libitum* purified diets containing one of four different protein sources. The four sources of protein were 1) bacteria from roughage fed steers, 2) bacteria from concentrate fed steers, 3) soy protein and 4) zein protein. The protein sources were added to the purified diets to supply 10% true protein. The rats were fed and weighed daily for 10 days. At the end of the 10 days all rats were fasted for 24 hours and sacrificed. Carcasses were chopped, dried at 85^{o} C and digested in sulfuric acid. Nitrogen was determined in the carcasses and the feeds by the Kjeldahl method.

Results

The bacteria from the roughage fed and concentrate fed steers contained 53.55% amino acids on a dry basis. The amino acid compositions of the bacteria harvested from the two sources are presented in table 1. As can be seen from the data in this table, the concentrations of individual amino acids were very similar between bacterial sources. Likewise, the molar ratios of individual amino acids were very similar. The correlation in amino acid composition between sources for both concentration and molar ratio was .997 $\pm$ .020 ($P<.01$).

Presented in table 2 is the nitrogen composition of bacterial preparations. As can be seen from these data, both total nitrogen and amino nitrogen were very similar between the bacterial sources. Amino nitrogen as a percent of total nitrogen was 76.5% for the roughage bacteria and 76.1% for the concentrate bacteria. The bacterial proteins were found to contain approximately 13% nitrogen for both protein sources.

The results of the rat feeding trial are given in table 3. The rats consuming both the soy and concentrate bacteria diets had the highest nitrogen intakes and the rats consuming the zein diet had the lowest nitrogen intake. The differences in nitrogen intake are the result of different intakes of the diets. The daily gain was highest for the rats consuming the diet with concentrate bacteria as the protein source and was lowest for those fed the diet supplemented with zein. Daily gain was intermediate for the animals fed the diets supplemented with soy and roughage bacteria. Nitrogen retention was greatest for the rats fed the diet supplemented with the concentrate bacteria and was lowest for those fed the diet supplemented with zein.

The values for both Net Protein Utilization and Protein Efficiency Ratio indicate that the concentrate bacteria were of the greatest value to the rats. The corresponding values for the rats fed zein were negative, indicating a very low quality protein. The values for the soy and roughage bacteria were intermediate. When comparing the other sources of protein to soy, it was observed that the relative values of zein, roughage bacteria and concentrate bacteria were 62.83, 97.41 and 114.04% the value of soy protein.

From these data it would appear that, although the bacteria from both sources were the same in amino acid content, the bacteria from the steers fed the high concentrate ration were superior. The bacteria from the high roughage ration appear to be similar to soy in protein quality.

TABLE 1. AMINO ACID COMPOSITION OF RUMEN BACTERIA HARVESTED FROM ROUGHAGE AND CONCENTRATE FED STEERS

Amino acid	Concentration[a]		Molar ratio[b]	
	Roughage	Concentrate	Roughage	Concentrate
Aspartic	6.65	6.35	13.49	13.08
Threonine	2.81	2.71	5.70	5.59
Serine	1.90	1.90	3.85	3.92
Glutamic	6.46	6.60	13.11	13.60
Proline	1.44	1.40	2.93	2.88
Glycine	2.66	2.58	5.40	5.32
Alanine	3.57	3.49	7.26	7.18
Valine	3.09	3.11	6.27	6.41
Cystine	1.17	1.15	2.37	2.36
Methionine	1.21	1.21	2.47	2.49
Isoleucine	2.93	2.69	5.95	5.53
Leucine	3.63	3.78	7.37	7.78
Tyrosine	2.28	2.09	4.62	4.30
Phenylalanine	2.49	2.36	5.06	4.86
Lysine	3.90	3.87	7.93	7.97
Histidine	.86	.97	1.76	1.99
Arginine	2.20	2.30	4.46	4.73
Total	49.25	48.55	100.00	100.00

[a]Expressed as g/100 g air dry bacteria.
[b]Expressed as g/100 g total amino acids.

TABLE 2. NITROGEN COMPOSITION OF RUMEN BACTERIAL PREPARATIONS

Item	Bacterial source	
	Roughage	Concentrate
Total N, %[a]	9.0	9.1
Amino N, %[a]	6.9	7.0
Amino N as % of total N	76.5	76.1
N in bacterial protein, %	12.9	13.0

[a]Dry matter basis.

TABLE 3. COMPARISON OF NITROGEN INTAKE, DAILY GAIN, NITROGEN RETENTION, NET PROTEIN UTILIZATION, PROTEIN EFFICIENCY RATIO AND REPLACEMENT VALUE FOR FOUR DIETARY PROTEIN SOURCES

	Dietary protein source			
Item	Soy	Zein	Roughage bacteria	Concentrate bacteria
Nitrogen intake, g	1.43	.87	1.18	1.40
Daily gain, g	1.89	-1.11	1.73	3.03
Nitrogen retention, g[a]	.63	-.03	.47	.82
N.P.U.[b]	32.74	-2.69	29.80	46.83
P.E.R.[c]	1.52	-1.50	1.39	2.21
Replacement value, %[d]	100.00	62.83	97.41	114.04

[a]Determined as gain in carcass nitrogen content over rats sacrificed initially.
[b]Net Protein Utilization (N.P.U.) = nitrogen retained ÷ nitrogen intake.
[c]Protein Efficiency Ratio (P.E.R.) = weight gain ÷ protein intake.
[d]Replacement value = $100 - \left(\frac{\text{N retained, soy}}{\text{N intake, soy}} - \frac{\text{N retained, test}}{\text{N intake, test}} \times 100\right)$

PERFORMANCE AND LIVER COPPER LEVELS OF BEEF HEIFERS FED BROILER LITTER

K. E. Webb, Jr., J. P. Fontenot and W. H. McClure

Broiler litter, a solid waste from the poultry industry, has been shown to have substantial nutritive value. To date, however, the Food and Drug Administration does not sanction the use of broiler litter or any other animal waste as a feed ingredient. Some of their primary concerns are related to drug residues and heavy metal residues. The evaluation of broiler litter as a feed for ewes was reported in the 1972 Livestock Research Reports (V.P.I. & S.U. Res. Div. Rep. 145). In this study it was observed that the performance of ewes fed up to 50% broiler litter was comparable to that of ewes fed a control diet. However, the problem of copper toxicity arose in the ewes and this was related to the high copper content of the broiler litter resulting from the feeding of copper sulfate to the broiler chicks. In the 1974 Livestock Research Report (V.P.I. & S.U. Res. Div. Rep. 158) the results of an experiment of feeding broiler litter to cows was discussed. In that report it was indicated that feeding as high as 80% broiler litter as a wintering ration had no detrimental effects on the performance of cows. The present study was initiated at the Shenandoah Valley Research Station in December of 1972 and will continue for several years to evaluate the effect of long-term feeding of broiler litter on the performance of cows and upon the accumulation of copper in the liver of cows. Preliminary results of this experiment were presented in the 1974 Report.

Experimental Procedure

Forty-two weanling heifers were allotted at random by weight and breeding to three lots. The first winter (1972-73) the animals in lot 1 were fed 8.5 lb. of mixed hay, 3 lb. ear corn and 1 lb. of a complex urea supplement per head per day. The animals in lots 2 and 3 were self-fed a mixture of 50% broiler litter and 50% ear corn. Copper was added to the ration in lot 3 to supply an additional 100 ppm copper. During the second and third winters the heifers were fed the following rations: lot 1 - Hay; lot 2 - 75% broiler litter, 25% ground ear corn; and lot 3 - 75% broiler litter, 25% ground ear corn and 160 ppm supplemental copper. The litter used was removed from broiler houses bedded with wood shavings and was stacked in an open shed to go through a heat prior to feeding. The rations were fed in such amounts as to supply the TDN requirements.

The heifers were kept in small lots to minimize grazing. The cattle were weighed at 28-day intervals and feed consumption was recorded. Liver samples were obtained by biopsy each fall before the cattle were put on the wintering feed and each spring before they were turned to pasture.

The cattle grazed as a group during the summer on native pastures. The cattle were bred in the summer of 1974 and calved in the late winter and early spring of 1975. The animals will continue on experiment for 5 to 7 years. Liver samples will be obtained in the fall and in the spring of each year during the entire experiment.

Results

The average composition of the broiler litter fed to these heifers over the 3 years of this experiment is as follows: dry matter, 84.3%; crude protein, 32.6%; ether extract, 3.2%; crude fiber, 19.2%; ash, 16.2%; NFE, 28.8%; and copper, 64 ppm, dry basis. Data on ration consumption, average daily gain and calving performance are presented in table 1. As can be seen from the data in the table, ration consumption by the cattle was quite good and there are no particular trends for any of the rations. Average daily gains tend to indicate that the cattle fed litter rations gained slightly better during the first two wintering periods. However, the control cattle compensated for their slower winter gains during the summer grazing periods. The average daily gains listed for the period December 5, 1974 to April 24, 1975 show a loss in weight which reflects the loss from calving of the heifers.

Calving performance for this first calf crop has also been quite good. The numbers of calves born shows no detrimental effect of feeding broiler litter or broiler litter plus additional copper. In fact, more calves were born in the groups fed litter. Likewise, birth weights of the calves do not indicate any detrimental effect of feeding broiler litter.

The effect of feeding broiler litter on liver copper levels is presented in table 2. As can be seen from the data in this table, liver copper levels are highest in the spring following the feeding of broiler litter during the winter period. The levels of liver copper were lowest in the animals fed the conventional hay ration and highest for those animals fed the litter plus corn plus copper ration with the values for the litter plus corn ration being intermediate. It will be noted that at the end of the winter feeding periods copper is elevated in the liver of animals fed litter, especially those fed additional copper. However, these levels are not high enough to suspect a toxicity problem. By the end of the summer grazing period, the liver copper levels decline markedly and are only slightly above the levels observed in the control animals. This experiment is still in progress and to date no detrimental effects of feeding broiler litter as a wintering feed have been observed in these animals. This study will continue for several more years.

TABLE 1. EFFECT OF FEEDING BROILER LITTER TO HEIFERS ON RATION CONSUMPTION, AVERAGE DAILY GAIN AND CALVING PERFORMANCE

Parameter	Wintering ration		
	Hay	Litter + corn	Litter + corn + copper
No. of cows	14	14	14
Ration consumption, lb./head/day			
12-13-72 to 5-10-73	12.3	11.4	13.4
1-7-74 to 4-15-74	16.5	16.1	17.2
12-5-74 to 4-24-75	14.5	13.0	12.8
Average daily gain, lb.			
12-13-72 to 5-10-73	.58	.84	.90
1-7-74 to 4-15-74	.53	1.06	1.09
12-5-74 to 4-24-75[a]	-1.24	-1.36	-1.12
Calving performance			
Gain before calving, lb.	-63	-40	16
No. calves born	11	12	14
Birth wt. of calves, lb.	64	66	67

[a]Includes loss of weight due to calving.

TABLE 2. EFFECT OF FEEDING BROILER LITTER TO HEIFERS ON LIVER COPPER LEVELS

Sampling date	Wintering ration		
	Hay	Litter + corn	Litter + corn + copper
	ppm[a]		
12-12-72	44.8	31.9	27.6
5-4-73	109.8	300.2	773.0
12-2-73	68.6	106.7	158.0
4-17-74	73.0	197.3	729.5
12-4-74	136.1	178.5	239.3
4-29-75	51.1	251.1	669.8

[a]Dry basis.

FERMENTATION, UTILIZATION AND PALATABILITY OF BROILER LITTER ENSILED WITH HIGH MOISTURE CORN GRAIN

L. F. Caswell, J. P. Fontenot and K. E. Webb, Jr.

Ensiling has been used to preserve various crops, by-products and wastes and to make certain feedstuffs more acceptable to livestock. Ensiling broiler litter with high moisture corn grain may result in a number of benefits, including improved nutritive value of the corn, enhanced palatability of the litter and a final product that would approach a complete feed.

The present experiment was conducted to study the fermentation characteristics of an ensiled mixture of broiler litter and high moisture corn grain and to assess the digestibility, nitrogen utilization and palatability of rations containing the ensiled mixture.

Experimental Procedure

High moisture corn grain, containing 26% moisture, was harvested and ensiled the same day, both alone and in a 2 to 1 ratio, by weight, with wood shaving based broiler litter containing 19% moisture and 37% crude protein, dry basis. One group of broilers had been reared on the litter which was obtained from one commercial broiler house. The birds had been fed the drugs, amprolium, ethopabate, monensin sodium, roxarsone, sulfaquinoxaline and zinc bacitracin.

The corn grain and the litter were ground in a hammer mill, through a 1/4 in. screen prior to being placed in each of six silos for the corn and two silos for the corn-litter mixture. Each silo consisted of a plywood box with cubic dimensions of 4 ft. lined with two polyethylene bags. A total of 2250 lb. of corn or corn-litter mixture was placed in each silo. After filling, a thermistor probe was inserted into the ensiled mass to a depth of 1 ft. and both polyethylene bags were individually twisted and sealed around the thermistor probe lead. An attempt was made to expel as much of the air above the ensiled mass as possible before sealing the bags. Silo temperature measurements were made daily.

Three of the corn and one of the corn-litter silos were opened after 80 days. The fermented materials from these silos were fed in a metabolism trial with sheep and in the first of two palatability trials with cattle. The remaining four silos were opened for feeding at the beginning of the second palatability trial. Each silo was sampled daily at feeding, and the samples periodically were composited according to type of ensiled material and frozen for subsequent chemical analyses. Samples for microbiological determinations were obtained from each silo upon opening and on the last day of feeding from that silo.

Samples of the initial and fermented materials were analyzed for dry matter, crude fiber, ether extract, ash, NFE, total nitrogen (crude protein), protein nitrogen, non-protein nitrogen, uric acid nitrogen, ammonia nitrogen, arsenic (as a measure of roxarsone), amprolium, ethopabate, monensin sodium, sulfaquinoxaline and zinc bacitracin. Total bacteria and coliform counts were also performed, and qualitative tests were conducted for salmonella, shigella and proteus. Water extracts of the initial and fermented materials were subjected to pH measurement and analyzed for water soluble carbohydrates, lactic acid and volatile fatty acids.

The metabolism trial was conducted with 24 crossbred wethers averaging 76 lb., initially. The sheep were randomly allotted to the following rations: 1) ensiled corn (control, low protein); 2) ensiled corn-litter; 3) ensiled corn and processed litter; and 4) ensiled corn and soybean meal. The ingredient and chemical compositions of the rations are shown in table 1. Calculated crude protein content was equalized among the ensiled corn-litter, ensiled corn and processed litter and ensiled corn and soybean meal rations. Contributions to total ration crude protein from litter or soybean meal were 56.5, 64.4 and 58.6% for the ensiled corn-litter, ensiled corn and processed litter and ensiled corn and soybean meal rations, respectively. The processed litter consisted of the litter from the same house as the ensiled material. It was ground through a 1/4 in. mesh screen and dry heat processed in a forced-draft oven at 500°F for 30 min. with the litter at a depth of 1/2 in. Nitrogen loss as a result of processing was approximately 20%.

In an attempt to equalize dry matter intake, the sheep were fed 700, 684, 662 and 684 g of the rations designated as ensiled corn, ensiled corn-litter, ensiled corn and processed litter and ensiled corn and soybean meal, respectively, plus 10 g of iodized salt (containing 770 and 200 IU of vitamins A and D, respectively) per day in two equal feedings, at 7:30 a.m. and 7:30 p.m. Water was available _ad libitum_ except during the 2-hour feeding periods.

The trial consisted of a 10-day preliminary period followed by a 10-day collection period during which total urine and feces were collected. At the end of the collection period, samples of rumen coments were taken with a stomach tube 2 hours after the morning feeding. Rumen contents were strained and pH of the strained fluid was determined electrometrically. Analyses for ammonia nitrogen and volatile fatty acids were performed on the strained fluid. Jugular blood samples were taken on the same day 6 hours after the morning feeding and were analyzed for blood urea.

Two palatability trials were conducted with 12 Shorthorn, Hereford and Angus steer calves averaging 550 lb. Each trial consisted of a 10-day adjustment period followed by a 15-day intake measurement period.

The composition of the experimental rations fed is shown in table 2. The four rations contained the same major ingredients as those used in the metabolism trial described above. Calculated crude fiber levels were equalized among the rations by varying the amounts of corn cobs. The corn cobs were ground through a 1/2 in. mesh screen. For the two rations containing litter, 27.5% of the total ration dry matter was contributed by litter. The calves had access to trace mineralized salt in block form while confined to individual stalls. An intramuscular injection of 2,000,000 IU of vitamin A was given to each animal prior to trial 1.

The cattle were fed the respective rations once daily while confined to individual stalls for a period of 16 hours (3:00 p.m. to 7:00 a.m.). They were kept as a group in an exercise lot the remainder of the time. Water was available only in the exercise lot. An attempt was made to feed approximately 5 to 10% in excess of consumption. From the 11th through the 25th day of each trial, 5% of the daily refusal from each animal was stored below freezing in individual polyethylene bags. At the end of each trial these samples were composited by animal and used for dry matter determination. While in the stalls, eating patterns of the individual steers were measured during the last 15 days of each trial using photoelectric relays and an operation recorder.

Results

The composition of the high moisture corn grain and broiler litter ensiled in this study is given in table 3. Analysis of the corn grain for nitrogen components indicated that a relatively small portion of the total nitrogen was in the form of non-protein nitrogen. Fractionation of total nitrogen in the litter indicated that levels of nitrogen components were normal. Temperatures of the ensiled materials generally reflected ambient temperature.

The composition of the initial and fermented corn and corn-litter mixtures, shown in table 4, was essentially unchanged as a result of fermentation. The addition of litter to corn grain elevated the crude protein content to about 20%.

Fermentation characteristics of both the initial and fermented materials are presented in table 5. A significant ($P < .01$) difference in pH existed between treatments initially. Following fermentation, pH values were still significantly ($P < .01$) different between materials. It had dropped about 1.7 units for the fermented corn, as compared to a drop of only 0.7 unit for the corn-litter mixture. Lactic and acetic acids were elevated to similar levels between treatments by fermentation, but water soluble carbohydrate levels differed significantly ($P < .05$).

In table 6 are shown the nitrogen components of the initial and fermented products. Total nitrogen content of the two feeds was not changed by ensiling. Of particular importance is the fact that both materials showed a substantial decrease in protein nitrogen as a result of fermentation. Accompanying this response was a substantial increase in ammonia nitrogen in both cases. In the corn-litter mixture, hydrolysis of uric acid also apparently made a significant contribution to ammonia nitrogen.

The results of total bacteria and coliform counts and the qualitative tests for salmonella, shigella and proteus performed on the initial and fermented materials are shown in table 7. Initially, total bacteria and coliform counts were quite high for the two materials, and the corn-litter mixture gave a positive test for proteus. Following fermentation, the total bacteria counts were 3.7 and 8.5% of the initial counts for the corn and the corn-litter mixture, respectively. Though greatly reduced, coliforms were still present after ensiling. However, the coliform number tended to be lower for the ensiled corn-litter mixture than for the ensiled corn. Proteus survived the ensiling.

In table 8 are shown the levels of arsenic and a number of medicinal drugs in the initial and fermented corn-litter mixture. Fermentation had no effect on the levels of arsenic or amprolium. No detectable levels of ethopabate or monensin sodium were found in the initial or fermented samples. Sulfaquinoxaline was significantly ($P < .01$) reduced from 71.3 ppm initially to 43.6 ppm after fermentation. Bacitracin was present in the initial corn-litter mixture at a level of 0.095 units per gram but was not detected in the fermented material.

Data on nitrogen utilization and apparent digestibility are presented in table 9. Nitrogen retention was significantly ($P < .01$) lower for the unsupplemented rations than for the rations containing litter or soybean meal. Retention expressed in grams per day and as a percent of intake was significantly ($P < .01$) higher for the ration supplemented with soybean meal than for either of the rations containing litter. This was due primarily to lower ($P < .01$) fecal nitrogen excretion by sheep fed the soybean meal supplemented ration. Expressed as a percent of absorbed, nitrogen retention for the ration containing the ensiled corn-litter mixture was not significantly different from the soy supplemented diet. Although retention was lower for the litter-fed than the soy-fed sheep, it is evident that the litter nitrogen was utilized quite efficiently, if the results are compared to those for sheep fed the low protein ration.

Coefficients of apparent digestibility were usually significantly ($P < .01$) lower for the low protein than for the supplemented rations. An exception to this was ether extract. Apparent digestibility of crude protein was lower ($P < .01$) for both litter-containing rations than for the soybean meal supplemented ration. Digestion coefficients for dry matter, crude fiber and NFE were not significantly different among the litter and soybean meal supplemented treatments.

In table 10 are shown the ruminal fluid pH and ammonia nitrogen and blood urea data from the metabolism trial. Ruminal fluid pH was not significantly affected by treatment. The ruminal fluid ammonia nitrogen value of 24.3 mg/100 ml for the ensiled corn and processed litter treatment was significantly ($P < .01$) higher than for the ensiled corn and soybean meal ration and the low protein ration. Values for the two litter-containing rations were not significantly different. Blood urea levels followed the same general trend as the ruminal fluid ammonia nitrogen levels.

In table 11 are shown the concentrations of ruminal fluid volatile fatty acids in sheep fed the four experimental diets. Expressed as μ moles per milliliter, acetic was significantly ($P < .01$) lower for lambs fed the low protein diet than for those fed the ration supplemented with processed litter. Propionic was significantly ($P < .05$) lower for animals fed the low protein ration than for those fed the rations supplemented with processed litter or soybean meal. Total VFA levels were also significantly ($P < .01$) lower for the control ration than for the treatments in which processed litter or soybean meal supplied additional nitrogen. None of the volatile fatty acids were significantly affected by treatment when expressed as moles/100 moles. Generally, VFA patterns for the lambs fed processed or ensiled litter were similar to that of animals fed soybean meal.

The dry matter intake data of the steers are presented in table 12. Dry matter intakes were 5.94, 7.32, 7.20 and 7.04 kg per day for the ensiled corn, ensiled corn-litter, ensiled corn and processed litter and ensiled corn and soybean meal rations, respectively. All three supplemented rations were consumed in significantly ($P < .01$) greater amounts than the unsupplemented ration. The values for the rations containing litter were not significantly different from the conventional soybean meal supplemented ration. There was, however, a trend for consumption to be slightly greater for the rations containing litter than for the ration containing soybean meal. In terms of grams per unit of metabolic size, intakes for the rations containing litter were nearly identical and were not significantly different from the soy ration.

The eating patterns of the cattle, presented in table 13, generally showed that the time spent eating was not markedly different among rations. The amount of each ration consumed was not necessarily reflected in the time spent eating.

Results of this study indicate that litter fermented with high moisture corn grain appears to be a reasonable approach to utilization of the waste as well as a feasible system of fattening cattle since this material was satisfactorily metabolized when fed to sheep and was readily accepted when offered to beef steers. Additional research is needed to evaluate the utilization and palatability of mixtures containing a greater proportion of litter. This would mean that a greater quantity of the waste would be disposed of, and the cost of feeding the mixture may be lowered. Also, fermented mixtures should be fed experimentally in long term trials in which performance is measured.

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS FED IN METABOLISM TRIAL

Item	Ration designation			
	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
Ingredient composition, %				
Ground corn cobs	50.0	50.0	50.0	50.0
Ensiled ground corn grain	49.7	---	27.2	37.2
Ensiled corn-litter mixture	---	50.0	---	---
Processed litter	---	---	22.8	---
Soybean meal[a]	---	---	---	12.6
Limestone	0.1	---	---	0.2
Defluorinated phosphate	0.2	---	---	---
Chemical composition				
Dry matter, %	83.5	86.2	87.9	85.8
Composition of dry matter, %				
Crude protein	6.3	10.8	11.1	11.7
Ether extract	1.6	1.3	1.3	1.3
Crude fiber	24.5	27.6	28.9	26.1
Ash	2.6	4.0	4.8	2.8
NFE	65.0	56.3	53.9	58.1

[a]Solvent processed, 44% crude protein guaranteed.

TABLE 2. COMPOSITION OF EXPERIMENTAL RATIONS FED IN PALATABILITY TRIALS

Item	Ration designation			
	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
Ingredient composition, %				
Ground corn cobs	30.0	20.0	20.0	28.4
Ensiled ground corn grain	69.1	---	56.3	55.9
Ensiled corn-litter mixture	---	80.0	---	---
Processed litter	---	---	23.7	---
Soybean meal[a]	---	---	---	14.9
Limestone	0.3	---	---	0.6
Defluorinated phosphate	0.6	---	---	0.2
Chemical composition				
Dry matter, %	79.9	81.6	82.5	81.9
Composition of dry matter, %				
Crude protein	6.9	16.0	13.5	13.5
Ether extract	2.1	2.2	2.2	1.9
Crude fiber	17.6	16.6	17.5	17.6
Ash	2.8	5.0	4.7	3.2
NFE	70.6	60.2	62.1	63.8

[a]Solvent processed, 44% crude protein guaranteed.

TABLE 3. COMPOSITION OF HIGH MOISTURE CORN GRAIN AND BROILER LITTER[a]

Item	High moisture corn grain	Broiler litter
Dry matter, %	73.7	81.3
Composition of dry matter, %		
Crude protein	9.5	37.3
Ether extract	2.9	2.8
Crude fiber	4.7	19.3
Ash	1.3	13.3
NFE	81.6	27.3
Water-soluble carbohydrates	3.6	2.6
Total nitrogen	1.5	6.0
Composition of total nitrogen, %		
Protein nitrogen	93.5	44.0
Non-protein nitrogen	6.5	56.0
Uric acid nitrogen	0	34.0
Ammonia nitrogen	1.0	14.1

[a]Values represent an average of eight samples of corn grain and two samples of litter.

TABLE 4. COMPOSITION OF INITIAL AND FERMENTED MATERIALS

Type of material	Dry matter	Composition of dry matter				
		Crude protein	Ether extract	Crude fiber	Ash	NFE
	%	%	%	%	%	%
Initial						
Corn	73.7[a]	9.4[a]	2.66	4.88[a]	1.28[a]	81.8[a]
Corn-litter mixture	76.6[b]	19.5[b]	2.69	9.58[b]	5.60[b]	62.6[b]
Fermented						
Corn	74.3[c]	9.4[c]	2.67	4.89[c]	1.27[c]	81.8[c]
Corn-litter mixture	79.0[d]	20.1[d]	2.61	9.01[d]	5.71[d]	62.6[d]

[a,b]Means for initial materials having different superscripts are significantly (P<.01) different.

[c,d]Means for fermented materials having different superscripts are significantly (P<.01) different.

TABLE 5. FERMENTATION CHARACTERISTICS OF INITIAL AND FERMENTED MATERIALS

Type of material	pH	Level, % of dry matter		
		Lactic acid	Acetic acid	Water-soluble carbohydrates
Initial				
Corn	6.23[a]	0	0[a]	3.56
Corn-litter mixture	7.50[b]	0	0.19[b]	3.38
Fermented				
Corn	4.67[c]	0.49	0.23	2.54[e]
Corn-litter mixture	6.77[d]	0.49	0.25	2.95[f]

[a,b]Means for initial materials having different superscripts are significantly (P<.01) different.
[c,d]Means for fermented materials having different superscripts are significantly (P<.01) different.
[e,f]Means for fermented materials having different superscripts are significantly (P<.05) different.

TABLE 6. NITROGEN COMPONENTS OF INITIAL AND FERMENTED MATERIALS

Type of material	Total nitrogen	Composition of total nitrogen			
		Protein nitrogen	Non-protein nitrogen	Uric acid nitrogen	Ammonia nitrogen
	% of DM	%	%	%	%
Initial					
Corn	1.51^{a}	93.2^{a}	6.8^{a}	0^{a}	1.0^{a}
Corn-litter mixture	3.12^{b}	75.4^{b}	24.6^{b}	18.6^{b}	10.6^{b}
Fermented					
Corn	1.50^{c}	83.3^{c}	16.7^{c}	0^{c}	3.2^{c}
Corn-litter mixture	3.22^{d}	67.1^{d}	32.9^{d}	13.0^{d}	13.2^{d}

[a,b]Means for initial materials having different superscripts are significantly (P<.01) different.

[c,d]Means for fermented materials having different superscripts are significantly (P<.01) different.

TABLE 7. BACTERIA COUNTS OF INITIAL AND FERMENTED MATERIALS

Type of material	Total bacteria	Coliforms	Salmonella	Shigella	Proteus
	10^9 per gram	10^3 per gram			
Initial					
Corn	0.807	695	-	-	-
Corn-litter mixture	1.470	290	-	-	+
Fermented					
Corn	0.030[a]	0.199	-	-	-
Corn-litter mixture	0.117[b]	0.149	-	-	+

[a,b]Means for fermented materials having different superscripts are significantly ($P<.05$) different.

TABLE 8. ARSENIC AND MEDICINAL DRUG RESIDUES[a] IN INITIAL AND FERMENTED CORN-LITTER MIXTURES

Item	Initial	Fermented
Arsenic,[b] ppm	1.4	1.8
Amprolium,[c] ppm	18.9	17.7
Ethopabate,[b] ppm	0	0
Monensin sodium,[b] ppm	0	0
Sulfaquinoxaline,[c] ppm	71.3[d]	43.6[e]
Zinc bacitracin,[b] units/g	0.095	0

[a]Values expressed on dry basis.
[b]Analysis performed on one composited sample representing all initial mixture samples and on one composited sample representing all fermented mixture samples.
[c]Analysis performed on individual samples following examination of data from composited samples.
[d,e]Means with different superscripts are different ($P < .01$).

TABLE 9. NITROGEN UTILIZATION AND APPARENT DIGESTIBILITY BY SHEEP

Item	Ration designation			
	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
Nitrogen utilization				
Nitrogen intake, g/day	5.63	10.22	10.35	10.97
Nitrogen excretion, g/day				
Fecal	3.53^{a}	4.02^{b}	4.26^{b}	3.60^{a}
Urinary	2.47^{a}	5.01^{b}	5.44^{b}	5.10^{b}
Total	6.00^{a}	$9.03^{b,c}$	9.70^{b}	8.70^{c}
Nitrogen retention				
Grams per day	-0.37^{a}	1.19^{b}	0.65^{b}	2.28^{c}
Percent of intake	-6.9^{a}	11.7^{b}	6.6^{b}	20.7^{c}
Percent of absorbed	-10.4^{a}	$19.3^{b,c}$	11.1^{b}	30.8^{c}
Apparent digestibility, %				
Dry matter	53.6^{a}	68.7^{b}	65.8^{b}	68.8^{b}
Crude protein	37.2^{a}	60.7^{b}	58.9^{b}	67.2^{c}
Ether extract	76.6^{a}	62.2^{b}	$63.5^{b,c}$	69.3^{c}
Crude fiber	30.3^{a}	67.9^{b}	65.4^{b}	62.8^{b}
NFE	64.5^{a}	73.2^{b}	$68.9^{a,b}$	72.9^{b}

^{a,b,c}Means having different superscripts are significantly ($P<.01$) different.

TABLE 10. RUMINAL FLUID pH AND AMMONIA NITROGEN AND BLOOD UREA OF SHEEP

	Ration designation			
Item	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
Ruminal fluid				
pH	6.48	6.67	6.61	6.51
NH_3-N, mg/100 ml	5.3[a]	20.3[b,c]	24.3[b]	14.1[c]
Blood urea, mg/100 ml	5.9[a]	21.0[b]	22.0[b]	18.0[b]

[a,b,c]Means having different superscripts are significantly ($P<.01$) different.

TABLE 11. RUMINAL FLUID VOLATILE FATTY ACID CONCENTRATIONS OF SHEEP

Item	Ration designation			
	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
Volatile fatty acids, μ moles/ml				
Acetic	31.7[a]	37.6[a,b]	44.0[b]	40.8[a,b]
Propionic	12.6[c]	13.7[c,d]	16.0[d,e]	16.9[e]
Butyric	5.2	5.1	5.1	7.1
Valeric	1.1	0.4	0.8	0.7
Isobutyric	1.5	1.5	1.8	1.5
Isovaleric	0.7[a]	1.1[a,b]	1.3[b]	1.1[a,b]
Total	52.8[a]	59.2[a,b]	68.9[b]	68.0[b]
Volatile fatty acids, moles/100 moles				
Acetic	59.7	63.5	63.8	59.9
Propionic	24.0	23.2	23.3	25.0
Butyric	9.6	8.6	7.2	10.5
Valeric	2.2	0.6	1.1	1.0
Isobutyric	3.0	2.4	2.7	2.1
Isovaleric	1.5	1.8	1.9	1.7

[a,b]Means having different superscripts are significantly ($P<.01$) different.

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

TABLE 12. DRY MATTER INTAKE BY CATTLE

Item	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
	Ration designation			
Kilograms per day	5.94[a]	7.32[b]	7.20[b]	7.04[b]
Grams per $W_{kg}^{0.75}$ per day	95.4[a]	115.0[b]	115.0[b]	107.9[a,b]

[a,b]Means having different superscripts are significantly (P<.01) different.

TABLE 13. EATING PATTERNS OF CATTLE

		Ration designation			
Days	Hours	Ensiled corn	Ensiled corn-litter	Ensiled corn + proc. litter	Ensiled corn + soybean meal
		min./hr.			
1 to 3	0 to 3[a]	14.0	16.3	15.8	14.8
	3 to 6[b]	10.9	11.6	12.9	10.4
	6 to 16[c]	4.8	5.4	6.3	5.6
3 to 6	0 to 3	15.9	15.4	13.3	15.2
	3 to 6	9.7	11.3	11.9	10.3
	6 to 16	4.3	5.9	5.4	5.7
6 to 9	0 to 3	17.5	16.8	18.6	16.7
	3 to 6	12.1	12.5	11.9	11.1
	6 to 16	4.9[d]	6.4[e]	5.7[d,e]	6.0[e]
9 to 12	0 to 3	18.6	17.1	20.3	18.4
	3 to 6	10.4	11.3	10.0	10.9
	6 to 16	4.3	6.4	6.1	5.5
12 to 15	0 to 3	17.4	13.8	19.0	14.0
	3 to 6	10.0	12.6	9.9	11.5
	6 to 16	4.9[d]	6.7[e]	5.6[d,e]	5.3[d]

[a]3:00 pm to 6:00 pm

[b]6:00 pm to 9:00 pm

[c]9:00 pm to 7:00 am

[d,e]Means within the same row having different superscripts are significantly ($P < .05$) different.

DIGESTIBILITY OF NUTRIENTS FROM ALFALFA HAY, CORN AND OATS BY PONIES

C. J. Carle, J. P. Fontenot and K. E. Webb, Jr.

Since the horse is a nonruminant herbivore, it possesses a simple stomach of the monogastric, and in addition, a large cecum, which performs similar digestive activities as the rumen. However, the cecum is located posterior to the small intestine, while the rumen of cattle and sheep preceeds the small intestine. So, although microbial activity does occur in the cecum, there is uncertainty as to the extent to which the nutrients are actually absorbed and available to the animal.

This research was conducted to determine the absorption of nutrients by ponies fed alfalfa hay from two sources, corn grain and oats grain.

Experimental Procedure

Eight mature gelding ponies averaging about 500 lb. were assigned to two groups (blocks) on the basis of weight. A 4 x 4 Latin square design was used. The experiment consisted of four trials, in which one animal from each group was fed one of the four test rations. This design afforded eight observations per ration at the end of the four trials.

The four experimental rations consisted of 1) alfalfa hay no. 1, 2) alfalfa hay no. 2, 3) alfalfa hay no. 1 and shelled corn, and 4) alfalfa hay no. 1 and whole oats. Alfalfa hay no. 1 was from Southwest Virginia and no. 2 was from the Richmond area. The no. 2 hay was somewhat leafier and finer textured than the no. 1 hay. They were both sun cured. The hay-grain diets consisted of hay and grain in a 1:1 ratio. Chromic oxide was incorporated at 0.5% of the diets, for comparing the total collection method and the indicator method of determining digestibility. The composition of the experimental rations is presented in table 1. All diets were adequate in dry matter intake, crude protein, calcium and phosphorus, according to NRC requirements. All diets were similar in dry matter and phosphorus. The straight hay rations were somewhat higher in crude protein, crude fiber, ash, calcium and magnesium, while the hay-grain diets were higher in ether extract and NFE.

The ration ingredients were ground in a hammermill through a 1/4 in. screen and mixed thoroughly. The rations were then pelleted through a 3/16 in. die. Pellets were similar in physical appearance among rations and were consumed readily.

Each trial consisted of a 7-day preliminary period in which the animals were adjusted to the experimental ration and feeding routine, followed by a 7-day collection period during which total fecal collections were made.

Each animal was fed 3.3 lb. of the pelletted ration three times daily (a total of 9.9 lb. of feed per day). The feeding periods were regularly spaced at 8-hour intervals. All animals were tied to prevent copraphagy, and were exercised daily.

During the collection periods a fecal collection bag was attached to each animal by means of a specially-designed harness. The collection bags were constructed from heavy weight canvas and were efficient in collecting all fecal excreta. The harnesses were constructed of 2-in. nylon webbing with 1-in. straps which attached to the bags.

The bags were changed prior to each feeding. The three excretions collected each day were composited in cans for each horse, and were weighed at the end of each day. The daily feces were then mixed thoroughly and a 5% sample was preserved by adding a pinch of thymol and were refrigerated. At the end of the collection period, the samples of excreta for the individual animals were composited for analysis.

Jugular blood samples were drawn at the conclusion of each collection period. The animals were fed a grass hay-shelled corn diet for a 3-week period between each trial.

The wet feces were analyzed for crude protein. The feces were dried prior to the determination of moisture, ether extract, crude fiber, ash, calcium, phosphorus and magnesium. The rations were sampled at each feeding, starting with the beginning of the collection period and were analyzed for proximate composition, calcium, phosphorus and magnesium. The apparent absorption of mineral components and digestibility of proximate constituents were determined by subtracting fecal excretion from intake, and digestibility of the grains was determined by difference. Blood serum was analyzed for calcium, inorganic phosphorus and magnesium.

Results

Table 2 presents the apparent digestibility of ration dry matter, crude protein and crude fiber. Dry matter digestibility of the alfalfa hays was slightly over 50%, and was higher for the leafier no. 2 hay. Dry matter digestibility was increased by the addition of grain to the hay rations, and was higher for the corn-hay than for the hay-oats ration. Dry matter in corn was found to be about 78% digested while in oats it was only 69% digested.

Apparent digestibility of crude protein was about 67% for the alfalfa hay no. 1, hay-corn diets, and corn alone. The digestibility of crude protein was greater in the alfalfa hay no. 2 and hay-oat diets, averaging 72%, while it was highest for oats alone, at 84%.

Crude fiber digestibility was greatest in the two alfalfa hay diets, nearly 50%, and these rations contained the highest amounts of fiber. The hay-grain diets were lower in fiber content and also lower in crude fiber digestibility, averaging 40%. Fiber digestibility of the grains, calculated by difference, was even lower, 31% for corn and 21% for oats.

Apparent absorption of phosphorus was greatest from the hay-oat ration, 19%, and lowest in the alfalfa hay no. 1 ration, about 15% (table 3). Apparent absorption from corn alone was 18%, while it was over 22% in oats.

Apparent absorption of magnesium varied from 30 to 40% among rations. Availability was about 41% in oats alone, while magnesium absorption from corn was calculated to be over 54%.

Blood serum composition is shown in Table 4. Serum calcium was similar among all rations at 12.2 mg/100 ml. Magnesium was similar for the ponies fed all rations. Serum inorganic phosphorus appeared to increase with increasing absorption of phosphorus from the rations. Serum phosphorus was lowest in the ponies fed alfalfa hay no. 1 diet, 4.1 mg/100 ml., and was highest for those fed the hay-oats diet (4.6 mg/100 ml.).

TABLE 1. CHEMICAL COMPOSITION OF RATIONS

Component	Alfalfa hay no. 1	Alfalfa hay no. 2	Corn-hay	Oats-hay
Dry matter, %	89.46	90.10	89.58	89.36
Composition of dry matter, %				
Crude protein	16.07	19.26	12.68	14.20
Ether extract	1.59	2.11	2.42	3.16
Crude fiber	30.70	27.24	17.62	20.90
Ash	8.61	7.90	5.54	6.10
NFE	32.26	33.58	51.32	44.65
Calcium	.99	1.08	.61	.54
Phosphorus	.32	.33	.30	.34
Magnesium	.26	.29	.20	.21

TABLE 2. APPARENT DIGESTIBILITY OF RATION COMPONENTS

Ration	Dry matter	Crude protein	Crude fiber
	%		
Alfalfa hay no. 1	53.4	66.6	49.1
Alfalfa hay no. 2	55.2	71.7	48.5
Corn-hay	65.8	66.7	38.0
Oats-hay	61.4	73.7	41.8
Corn[a]	78.2	67.0	30.7
Oats[a]	69.4	83.9	20.9

[a]Calculated by difference.

TABLE 3. APPARENT ABSORPTION OF PHOSPHORUS AND MAGNESIUM (%)

Ration	Mineral	
	Phosphorus	Magnesium
Alfalfa hay no. 1	14.9	30.7
Alfalfa hay no. 2	15.8	39.8
Corn-hay	16.5	39.1
Oats-hay	19.0	34.6
Corn[a]	18.1	54.3
Oats[a]	22.3	40.8

[a]Calculated by difference.

TABLE 4. BLOOD SERUM COMPOSITION

Ration	Calcium	Inorganic phosphorus	Magnesium
	- - - mg/100 ml. - - -		
Alfalfa hay no. 1	12.5	4.1	1.8
Alfalfa hay no. 2	12.2	4.2	1.7
Corn-hay	12.2	4.5	1.8
Oats-hay	12.2	4.6	1.8

SUPPLEMENTING PHOSPHORUS TO YOUNG THOROUGHBRED HORSES[1]

J. P. Fontenot, Janie Carle and K. E. Webb, Jr.

Bone abnormalities such as epiphysitis are serious problems in young developing thoroughbred horses. In earlier studies it was found that phosphorus supplementation increased hair phosphorus content in weanlings and yearlings, indicating that phosphorus nutrition may have been improved. During the transition at weaning, when the foals no longer have access to the mare's milk, mineral nutrition may be important.

A trial was conducted to evaluate the effect of mineral supplementation of young thoroughbreds on bone development and mineral levels in blood and hair.

Experimental Procedure

A total of 28 foals, 3-5 months of age, were started on test in July, 1974. At each of the three farms the foals were paired, according to sex, age and weight and allotted at random to the following treatments: 1) Control and 2) Phosphorus supplemented. The control horses receive their regular feed and the supplemented ones were supplemented with a sufficient amount of dicalcium phosphate to supply about one-half of the requirements for phosphorus, according to the National Research Council. The dicalcium phosphate was in a powdery form. It was mixed with sufficient limestone to produce a 2 to 1 calcium to phosphorus ratio. The supplement was mixed into the grain mix twice daily.

Before the foals were started on test they were weighed, samples of blood and hair were obtained and the first phalanx and third metacarpal bones were X-rayed. Weights, blood and hair samples and X-rays were taken at 3-month intervals. Feed samples were also taken at 3-month intervals.

The blood samples were analyzed for hemoglobin and hematocrit; the serum was analyzed for calcium, inorganic phosphorus, magnesium, protein, iron and copper; plasma was analyzed for glucose, urea, carotene and vitamin A. The hair samples were analyzed for calcium, phosphorus, iron and copper. Feed samples were analyzed for crude protein, ether extract, crude fiber, ash, NFE, calcium, phosphorus, magnesium, iron and copper.

[1]Supported in part by grants-in-aid from Keswick Stables, Cobham, Va., Little Hawk Farm, Crozier, Va. and Verulam Farm, Charlottesville, Va. The farms also made available horses and facilities for this equine research. Dr. Daniel Flynn, Charlottesville and Dr. Olive Britt, Ashland, cooperated, obtained blood samples and X-rayed the bones of the young horses.

Results

The weight changes of the young thoroughbreds from July to January are given in table 1. At all three farms phosphorus supplementation to the young horses tended to increase rate of gain. Average daily gains were 1.59 lb. for the controls and 1.67 lb. for those supplemented with phosphorus.

Serum inorganic phosphorus was not increased by phosphorus supplementation (table 2). In fact, there were trends for lower values for the supplemented horses. Blood composition generally appeared to be normal. Serum protein was somewhat lower than desired. There was a marked decline in blood glucose from July to October, probably a result of utilization of more roughage and no milk consumption by the developing horses. The composition of hair was not affected by supplementation (table 3).

The X-ray plates of the ankle bones indicated there were no differences in the time of closure of the epiphysis of the third metacarpal and first phalanx.

TABLE 1. EFFECT OF PHOSPHORUS SUPPLEMENTATION ON WEIGHT CHANGES OF YOUNG THOROUGHBREDS

Farm no.	Treatment	Wt. by date: July, 1974[a]	Wt. by date: Jan., 1975	Gain per head	Daily gain
		lb.			
1	Control	414	723	309	1.65
	Supplemented	400	721	321	1.72
2	Control	394	689	295	1.58
	Supplemented	396	714	318	1.70
3	Control	385	684	299	1.53
	Supplemented	386	695	309	1.58
1,2,3	Control	399	700	301	1.59
	Supplemented	395	711	316	1.67

[a]Before started on test.

TABLE 2. EFFECT OF PHOSPHORUS SUPPLEMENTATION ON BLOOD COMPOSITION OF YOUNG THOROUGHBREDS

			Blood		Blood serum						Blood plasma			
Farm no.	Month	Treatment	Hematocrit	Hemoglobin	Protein	Calcium	Inorganic phosphorus	Magnesium	Copper	Iron	Vitamin A	Carotene	Urea	Glucose
			%	g/100 ml	- - - - - -	- - - - - mg/100 ml	- - - - -		μg/100 ml	-	- - - μg/100 ml - -		- - mg/100 ml - -	
1	July[a]	Control	38.32	12.72	5.81	10.86	6.95	1.80	1.27	2.14	14.48	93.81	20.46	107.73
		Supplemented	39.80	13.47	5.86	11.26	7.16	1.85	1.34	2.51	21.06	121.72	17.53	113.45
	October	Control	40.05	13.91	6.29	11.71	6.12	1.88	1.33	4.33	23.49	92.39	27.06	62.89
		Supplemented	38.42	13.35	6.07	11.55	5.94	1.77	1.28	4.21	21.37	97.27	25.82	62.39
	January	Control	42.00	15.57	6.69	12.75	5.50	1.99	1.30	1.65	21.44	47.77	19.29	67.04
		Supplemented	41.90	15.41	6.59	12.52	5.48	1.85	1.29	1.65	18.96	53.47	17.22	62.48
2	July[a]	Control	36.70	12.37	6.05	11.14	7.33	1.86	1.45	2.08	23.75	122.11	17.35	83.56
		Supplemented	29.40	11.91	5.74	11.47	7.43	1.94	1.3-	2.46	25.38	178.30	15.45	83.92
	October	Control	36.90	13.14	6.09	11.67	6.38	1.70	1.77	4.16	21.00	88.50	26.18	84.69
		Supplemented	37.84	13.08	5.89	11.68	5.86	1.71	1.53	4.22	16.91	62.33	26.00	76.46
	January	Control	38.40	14.49	6.30	12.76	5.65	1.83	1.23	1.73	18.58	41.39	19.03	77.96
		Supplemented	40.60	14.96	6.52	12.51	5.06	1.76	1.12	1.56	16.19	26.94	18.26	73.81
3	July[a]	Control	37.35	12.30	6.16	11.19	6.96	1.88	1.72	1.62	14.23	69.60	18.14	85.03
		Supplemented	40.20	13.86	6.04	11.21	6.97	2.10	1.39	2.12	16.94	93.53	16.52	72.44
	October	Control	39.78	13.89	6.38	12.29	6.12	1.91	1.58	3.91	16.28	7.02	23.50	64.06
		Supplemented	39.78	14.68	6.06	12.29	5.39	1.85	1.34	3.81	16.78	9.12	22.04	67.59
	January	Control	37.28	13.95	5.96	13.14	5.62	2.00	1.20	1.80	17.08	6.63	19.67	87.98
		Supplemented	36.81	14.15	5.74	11.60	5.36	1.66	1.08	1.94	17.18	6.90	19.22	81.98
1,2,3	July[a]	Control	37.46	12.47	6.00	11.05	7.09	1.84	1.46	1.97	17.72	97.00	18.68	92.61
		Supplemented	36.23	13.02	5.87	11.32	7.20	1.95	1.37	2.38	21.43	133.87	16.58	91.75
	October	Control	38.85	13.63	6.24	11.86	6.21	1.82	1.56	4.15	20.54	66.61	25.73	71.[illegible]
		Supplemented	38.66	13.67	6.01	11.82	5.75	1.78	1.38	4.09	18.58	59.40	24.72	68.32

TABLE 2. (CONT.) EFFECT OF PHOSPHORUS SUPPLEMENTATION ON BLOOD COMPOSITION OF YOUNG THROUGHBREDS

			Blood		Blood serum							Blood plasma			
Farm no.	Month	Treatment	Hematocrit	Hemoglobin	Protein	Calcium	Inorganic phosphorus	Magnesium	Copper	Iron	Vitamin A	Carotene	Urea	Glucose
			%	g/100 ml	- - - - - -	- - - - -	mg/100 ml	- - - - -	μg/100	ml -	- - - μg/100	ml - -	- - mg/100	ml - -
1,2,3	January	Control	39.23	14.67	6.32	12.88	5.59	1.94	1.24	1.73	19.03	32.11	19.33	77.66
		Supplemented	39.77	14.84	6.28	12.21	5.30	1.76	1.16	1.72	17.44	29.10	18.23	72.76

[a] Before started on test.

TABLE 3. EFFECT OF PHOSPHORUS SUPPLEMENTATION ON HAIR COMPOSITION OF YOUNG THOROUGHBREDS

Farm no.	Month	Treatment	Calcium	Total phosphorus	Magnesium	Iron
			ppm			
1	July[a]	Control	2362	313	335	105.4
		Supplemented	4166	296	558	111.3
	October	Control	1640	378	175	57.0
		Supplemented	2090	413	282	74.0
	January	Control	1818	377	436	52.4
		Supplemented	2533	456	544	64.2
2	July[a]	Control	2767	365	547	111.5
		Supplemented	4303	343	477	89.5
	October	Control	2338	417	336	69.0
		Supplemented	1855	397	212	54.0
	January	Control	2488	396	496	63.4
		Supplemented	3323	367	412	76.2
3	July[a]	Control	2715	219	542	171.2
		Supplemented	3302	500	496	88.5
	October	Control	2314	443	336	47.0
		Supplemented	2217	459	359	43.0
	January	Control	1977	430	416	124.9
		Supplemented	1918	405	360	144.4
1,2,3	July[a]	Control	2607	305	470	126.4
		Supplemented	3968	371	511	97.0
	October	Control	2082	411	285	58.4
		Supplemented	2057	422	284	58.3
	January	Control	2094	401	449	80.2
		Supplemented	2591	409	439	94.9

[a]Before started on test.

TABLE 4. COMPOSITION OF FEED AND PASTURES - YOUNG THOROUGHBREDS

				Dry basis								
Farm no.	Month	Feed	Dry matter	Crude protein	Ether extract	Fiber	Ash	NFE	Calcium	Phosphorus	Magnesium	Copper	Iron
			%									ppm	
1	October	Concentrate	88.06	15.76	2.40	9.25	7.43	65.16	1.06	0.53	0.21	23.8	326.6
		Hay	89.28	10.92	1.45	35.89	6.63	45.11	0.78	0.19	0.19	11.2	87.4
		Pasture	32.27	13.39	3.37	27.89	12.95	45.09	0.57	0.35	0.28	11.8	419.0
2	"	Concentrate	86.06	17.66	3.40	9.90	5.86	63.18	0.68	0.54	0.20	20.4	187.9
		Hay	88.08	14.15	2.29	31.73	7.10	44.73	1.04	0.26	0.24	16.2	173.9
		Pasture	39.81	11.67	2.85	29.69	8.90	46.89	0.60	0.32	0.24	12.8	552.0
3		Concentrate	85.82	13.96	1.60	10.42	7.45	66.59	1.11	0.56	0.18	25.0	275.0
		Hay	89.78	16.08	1.90	29.90	7.89	44.23	0.92	0.42	0.27	17.0	122.0
		Pasture	33.33	12.61	2.48	28.35	7.33	49.23	0.46	0.25	0.26	26.0	211.0
1,2,3		Concentrate	86.65	15.79	2.47	9.86	6.91	64.98	0.95	0.54	0.20	23.1	263.2
		Hay	89.05	13.72	1.88	32.51	7.21	44.69	0.91	0.29	0.23	14.8	127.8
		Pasture	35.14	12.56	2.90	28.64	9.73	47.07	0.54	0.31	0.26	16.9	394.0
1	January	Concentrate	84.17	15.55	3.30	7.65	6.69	66.80	0.84	0.49	0.19	11.6	366.5
		Hay	88.21	15.80	1.94	27.99	7.80	46.47	1.03	0.19	0.19	12.5	113.4
2	"	Concentrate	86.44	17.83	5.12	7.52	4.38	65.16	0.31	0.46	0.15	10.3	210.0
		Hay	87.32	20.04	1.52	25.50	8.41	44.53	0.82	0.37	0.21	13.7	340.1
3	"	Concentrate	87.60	17.68	2.56	7.45	14.46	57.85	1.94	0.46	0.28	46.0	1202.8
		Hay	88.44	14.56	3.06	28.72	8.03	45.62	0.79	0.41	0.28	13.0	162.8
1,2,3	"	Concentrate	86.07	17.02	3.66	7.54	8.51	63.27	1.03	0.47	0.21	22.6	593.1
		Hay	87.99	16.80	2.17	27.40	8.08	45.54	0.88	0.32	0.23	13.1	205.4

NUTRITIONAL STATUS OF THOROUGHBRED HORSES[1]

J. P. Fontenot, Janie Carle and K. E. Webb, Jr.

Nutrition of horses is important to keep them healthy and functional. Two problems which plague the horse industry are poor reproductive rate and abnormal bone development and maintenance. These two problems can result from improper nutrition.

Three years ago we reported on the nutritional status of thoroughbreds (V.P.I. & S.U. Res. Div. Rep. 145, p. 20). It was found that although there did not appear to be serious nutrition problems, there were some indications that some nutrients may have been marginal, based mainly on blood levels of these. One of those was phosphorus level. Supplementation with this mineral appeared to be beneficial if the level in the feed was limited. The feeding program of one farm was modified in order to correct for a low level of feed phosphorus.

In order to further study the nutritional status of thoroughbred horses, mares from three farms were used during the past year.

Experimental Procedure

Blood samples were obtained from 10 mares from each of three thoroughbred farms at 3 month intervals. The mares were fed and managed in the regular manner for the particular farm. A record of the feeding system was obtained, and the feeds and pastures were sampled. Hair samples were obtained in July and October.

The blood samples were analyzed for hemoglobin and hematocrit; the serum was analyzed for calcium, inorganic phosphorus, magnesium, protein, iron and copper; plasma was analyzed for glucose, urea, carotene and vitamin A. The hair samples were analyzed for calcium, phosphorus, magnesium, iron and copper. Feed samples were analyzed for crude protein, ether extract, crude fiber, ash, NFE, calcium, phosphorus, magnesium, iron and copper.

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[1] Supported in part by grants-in-aid from Keswick Stables, Cobham, Va., Little Hawk Farm, Crozier, Va. and Verulam Farm, Charlottesville, Va. The farms also made available horses and facilities for this equine research. Dr. Daniel Flynn, Charlottesville and Dr. Olive Britt, Ashland cooperated, obtained blood samples and X-rayed the bones of the young horses.

Results

Generally, the blood values for the mares were normal at the four times sampled during the year (table 1). There were few differences among farms or seasons. Serum inorganic phosphorus values were consistently lower in January and October than in April and July. This may be related to availability of pasture, since there was only limited grazing in October, and none in January.

Blood plasma vitamin A levels were similar for the horses at the three farms at the four times sampled (table 1). However, plasma carotene was higher in April, probably a reflection of availability of green pasture.

Hair calcium and magnesium levels were lower in October than July for all farms (table 2). There were no other consistent trends.

The composition of the feeds and pasture for the farms at four times of the year are given in table 3. The composition of the feeds did not indicate any nutritional problem.

TABLE 1 . MONITORING OF BLOOD COMPOSITION OF THOROUGHBRED MARES

Farm no.	Month	Blood: Hematocrit	Blood: Hemoglobin	Blood serum: Protein	Blood serum: Calcium	Blood serum: Inorganic phosphorus	Blood serum: Magnesium	Blood serum: Copper	Blood serum: Iron	Blood plasma: Vitamin A	Blood plasma: Carotene	Blood plasma: Urea	Blood plasma: Glucose
		%	g/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	µg/100 ml	µg/100 ml	µg/100 ml	µg/100 ml	mg/100 ml	mg/100 ml
1	January	41.71	18.48	7.28	14.31	2.61	1.89	1.73	5.03	22.38	67.36	25.84	59.61
	April	44.04	14.29	8.12	12.94	3.18	2.20	0.72	2.92	22.67	126.39	33.02	59.24
	July	39.00	13.37	7.48	11.76	3.57	1.76	1.36	1.55	15.99	67.72	25.72	48.74
	October	46.89	16.38	7.76	11.53	2.94	1.93	1.21	4.22	24.76	87.45	25.30	53.16
2	January	42.45	17.70	7.44	13.29	3.06	1.75	1.66	2.58	25.74	34.66	28.05	59.84
	April	46.33	13.89	7.94	12.58	4.01	1.95	0.98	3.00	28.33	241.64	32.19	65.87
	July	37.72	12.08	7.63	11.82	3.75	1.85	1.27	1.53	24.52	88.20	29.72	51.97
	October	44.60	15.60	7.65	11.14	3.14	1.74	1.18	3.86	19.69	58.84	28.85	53.68
3	January	43.93	18.38	8.03	13.60	2.30	1.98	1.65	3.26	20.30	25.89	21.87	65.01
	April	41.08	13.86	7.47	13.20	3.70	1.96	0.76	3.15	28.94	182.95	32.97	61.43
	July	42.08	13.74	7.26	11.41	4.04	1.99	1.55	1.64	22.96	59.01	23.38	45.64
	October	44.31	15.19	7.26	12.34	3.03	2.09	1.18	4.29	28.78	149.93	19.00	55.36
1,2,3	January	42.55	18.14	7.53	13.72	2.72	1.85	1.68	3.60	23.27	44.14	28.20	60.99
	April	44.65	14.01	7.91	12.80	3.69	2.03	0.86	3.00	26.64	194.30	32.60	62.95
	July	39.07	12.88	7.50	11.71	3.74	1.85	1.36	1.56	21.14	74.86	26.99	49.51
	October	45.36	15.78	7.60	11.57	3.04	1.89	1.19	4.09	23.70	91.00	[illegible]	53.90

TABLE 2 . MONITORING OF HAIR COMPOSITION OF THOROUGHBRED MARES

Farm no.	Month	Calcium	Phosphorus	Magnesium	Iron
		ppm			
1	July	2052	340	405	137.9
	October	1550	362	186	103.0
2	July	3147	356	482	101.5
	October	1387	355	160	81.0
3	July	4714	465	596	87.2
	October	1515	375	228	58.0
1,2,3	July	3087	375	479	112.2
	October	1491	364	189	83.1

TABLE 3. COMPOSITION OF FEED AND PASTURE - MARES

Farm no.	Month	Feed	Dry matter	Crude protein	Ether extract	Fiber	Ash	NFE	Calcium	Phosphorus	Magnesium	Copper	Iron
				Dry basis									
			%									ppm	
1	January	Concentrate	86.90	13.29	3.41	9.01	4.11	70.17	0.24	0.23	0.20	15.69	147.80
		Hay	87.36	12.88	2.82	31.35	7.14	45.81	0.81	0.21	0.22	11.45	132.78
	April	Concentrate	85.18	15.47	4.26	7.33	6.72	66.22	0.95	0.52	0.20	64.46	298.42
		Hay	91.42	14.01	2.84	32.02	7.64	43.49	1.23	0.30	0.35	30.60	172.28
		Pasture	26.40	13.67	3.98	26.92	10.13	45.30	0.53	0.40	0.21	26.03	484.17
	July	Concentrate	86.03	18.89	2.54	9.61	7.10	61.85	1.19	0.55	0.27	16.12	443.28
		Hay	89.81	12.80	2.88	33.73	7.04	43.55	0.94	0.19	0.25	10.02	200.42
		Pasture	31.87	10.35	3.21	34.24	11.87	40.35	0.68	0.39	0.30	4.14	676.66
	October	Concentrate	88.06	15.76	2.40	9.25	7.43	65.16	1.06	0.53	0.21	23.80	326.60
		Hay	89.28	10.92	1.45	35.89	6.63	45.11	0.78	0.19	0.19	11.20	87.40
		Pasture	44.87	11.73	2.88	30.02	8.50	46.89	0.47	0.29	0.19	10.40	264.50
2	January	Concentrate	87.84	13.59	4.16	8.36	5.31	68.58	0.43	0.38	0.29	15.04	227.00
		Hay	89.94	15.21	2.73	30.54	7.00	44.52	0.95	0.23	0.26	13.35	137.96
	April	Concentrate	89.36	16.18	4.29	9.78	5.78	63.95	0.53	0.73	0.28	62.9	296.44
		Hay	92.56	15.22	2.63	29.87	7.40	44.88	1.17	0.27	0.25	68.05	198.62
		Pasture	24.50	17.79	3.78	23.68	8.09	46.65	0.52	0.37	0.16	35.30	313.08
	July	Concentrate	88.44	17.36	4.70	9.97	5.91	62.06	0.76	0.57	0.26	12.03	321.51
		Hay	90.97	13.99	2.89	30.70	6.52	45.90	1.38	0.23	0.29	7.77	158.00
		Pasture	40.78	11.40	2.44	31.02	8.11	67.85	0.73	0.35	0.26	8.06	233.75
	October	Concentrate	87.40	17.66	3.40	9.90	5.86	63.18	0.68	0.54	0.20	20.37	187.87
		Hay	88.08	14.15	2.29	31.73	7.10	44.73	1.04	0.26	0.24	16.20	173.92
		Pasture	40.91	11.17	2.88	31.31	8.16	46.47	0.51	0.32	0.22	13.50	316.90

TABLE 3. (CONT'D.). COMPOSITION OF FEED AND PASTURE - MARES

Farm no.	Month	Feed	Dry matter	Dry basis: Crude protein	Ether extract	Fiber	Ash	NFE	Calcium	Phosphorus	Magnesium	Copper	Iron
			%	%	%	%	%	%	%	%	%	ppm	ppm
3	January	Concentrate	85.96	16.04	3.50	8.98	9.44	62.06	1.05	0.50	0.34	25.61	453.49
		Hay	88.06	20.94	2.74	23.49	8.12	44.72	1.10	0.37	0.23	10.79	236.20
	April	Concentrate	88.54	17.23	4.10	10.04	8.20	60.42	1.27	0.78	0.33	80.14	384.47
		Hay	91.95	14.48	2.87	30.94	7.55	44.16	0.84	0.36	0.28	69.04	140.56
		Pasture	21.00	21.58	4.28	24.11	9.61	40.42	0.48	0.48	0.24	43.29	307.28
	July	Concentrate	87.54	16.31	3.22	10.72	7.75	62.00	1.39	0.71	0.33	22.12	371.48
		Hay	89.95	14.60	3.70	31.23	6.63	43.88	0.76	0.35	0.30	5.56	171.21
		Pasture	29.08	11.81	4.11	31.22	9.52	43.36	0.48	0.42	0.30	4.20	281.36
	October	Concentrate	85.82	13.96	1.60	10.42	7.45	66.59	1.11	0.56	0.18	25.00	275.00
		Hay	89.78	16.08	1.90	29.90	7.89	44.23	0.92	0.42	0.27	17.00	122.00
		Pasture	33.33	12.61	2.48	28.35	7.33	49.23	0.46	0.25	0.26	26.00	211.00
1,2,3	January	Concentrate	86.90	14.31	3.69	8.78	6.29	66.94	0.57	0.37	0.28	18.78	276.10
		Hay	88.45	16.34	2.76	28.46	7.42	45.02	0.95	0.27	0.24	11.86	168.98
	April	Concentrate	87.69	16.29	4.22	9.05	6.90	63.53	0.92	0.68	0.27	69.17	376.44
		Hay	91.98	14.57	2.78	30.94	7.53	44.18	1.08	0.31	0.29	55.90	170.49
		Pasture	23.97	17.68	4.01	24.90	9.28	44.12	0.51	0.42	0.20	34.88	368.18
	July	Concentrate	87.34	17.52	3.49	10.10	6.92	61.97	1.11	0.61	0.29	16.76	378.76
		Hay	90.24	13.80	3.16	31.89	6.73	44.44	1.03	0.26	0.28	7.76	176.54
		Pasture	33.91	11.19	3.25	32.16	9.83	50.52	0.63	0.39	0.29	5.47	397.36
	October	Concentrate	87.09	15.79	2.47	9.86	6.91	64.98	0.95	0.54	0.20	23.06	263.16
		Hay	89.05	13.72	1.88	32.51	7.21	44.69	0.91	0.29	0.23	14.80	127.77
		Pasture	39.70	11.84	2.75	29.89	8.00	47.53	0.48	0.29	0.22	16.63	264.13

MANAGEMENT AND NUTRITION OF EARLY WEANED PIGS. 1. EFFECT OF AGE AT WEANING UPON INCIDENCE OF SCOURS, PERFORMANCE AND SURVIVAL

E. T. Kornegay and J. D. Blaha

The successful raising of pigs weaned at one day of age offers a great possibility of increasing sow productivity by saving many of the pigs that would otherwise die. Some producers are interested merely in a system that might save extra pigs from large litters and pigs from sows that die or have milking problems. Other producers would like the means to wean all pigs at an early age so that the sows could be rebred for another litter. Still others may look at artificial raising of baby pigs as a way to break the cycle of some disease problems including internal parasites. Previous attempts have generally been unsuccessful due to a lack of knowledge concerning management and nutrition.

The major objective of the Virginia Tech baby pig research is to develop the management and nutrition necessary to raise pigs weaned from the sow at one day of age. An environmentally controlled room was constructed so as to minimize the effect of temperature and exposure to conditions present in other sections of the swine center.

There were numerous problems in getting a mechanical feeder set up and operating properly and certain modifications were necessary. Many of these problems could be avoided in the future. From a few pilot trials, it was realized that the number one problem was the control of scours or diarrhea that usually occurred 2 to 5 days after the pigs were weaned. A number of factors became apparent: 1) that the mechanical feeder, as such, was not causing the problem, 2) that few problems were encountered in getting the pigs to drink when first placed in the cages, 3) that pigs which received colostrum had a greater chance of survival, 4) that antibiotics as determined by sensitivity tests were in general ineffective in controlling the vomiting and scouring, 5) that kaopectate, milk of bismuth and milk withdrawal were effective in treating certain cases of scours, 6) that in order to keep down bacterial growth in the room, it was best to keep the room temperature at about 70° F with small heaters being used over the top rear of cages to provide heat for the pigs.

The objective of these two trials was to evaluate the effect of age at weaning upon the incidence of scours, performance and survival.

Procedures

In trial 1, 24 pigs were weaned at 11, 50, 95 and 143 hr. after farrowing and placed in individual cages. In trial 2, 24 pigs were weaned at 12, 49 and 97 hours. In both trials pigs were hand-fed 6 times each day with fortified whole cow's milk. Fortification per kilogram of milk was: 5 mg Cu, 50 mg

Fe, 50 mg Zn, 5000 I.U. vitamin A, 1000 I.U. vitamin D, 5 I.U. vitamin E and 70 gm dried skimmed milk. The liquid diet was stored in the refrigerator. Hand feeding of the liquid diet was necessary because the mechanical feeder would only dispense a dry diet. The fortified whole cow's milk was used in these first two trials because it had previously been shown by Dr. James Leece of N. C. State University to be adequate for raising early weaned pigs; however, this diet must be fed as a liquid. After about 14 days, a commercial milk replacer was mechanically fed every 90 minutes. Temperature in the room was kept about 70^{o} F. Small heaters over the end of the cage opposite the feed cups provided a temperature of about 100^{o} F in the cage. The pigs could move away from the heater if they desired.

Results and Discussion

Trial 1. It appeared that the time to first treatment (scours) was related more to date of farrowing than to date of weaning (table 1). Average daily gain appeared to be about the same regardless of weaning age. One pig from the 95 hour weaned group died 8 days after farrowing or 4 days after weaning. Two littermates to this pig, one weaned at 11 hours and one weaned at 50 hours were untreated and did well.

Trial 2. Four pigs died in this trial, 3 from the 12 hour weaned group and one from the 49 hour weaned group. The quality of pigs at birth in this trial was poor as compared to the pigs used in trial 1. Pigs at birth in trial 1 were 233 grams heavier than pigs in trial 2. The pig that died from the 49 hour weaned group lost 53 grams from farrowing to weaning which would suggest that he received little or no colostrum. The other three pigs, from the 12 hour weaned group received little or no colostrum as evidenced by their low gain (30 g average) from farrowing to weaning. Contrary to results of trial 1, time to first treatment (scours) appeared to be related more to the time after weaning than to the time from farrowing. Average daily gain was lower in trial 2 than in trial 1, which might reflect the poorer quality of the pigs used in trial 2.

A comparison of the final weight of mechanical fed and sow raised pigs showed little difference between the two groups. The final weight was 5.7 and 5.6 kg in trial 1 and 5.7 and 6.2 kg in trial 2, respectively, for mechanical fed and sow fed pigs.

Summary

Research has shown that pigs weaned at 12 hours can be raised; however, it is not a fool proof system and many questions remain unanswered. The number one problem in this system appears to be the prevention or control of scours which occurs during the first few days after the pig is weaned. Whether scours is related more to time after weaning or to time from farrowing is not clear from these two trials. Baby pigs start well and there are virtually no problems in getting pigs to drink. Growth rate is equal to and could be greater for artificially raised pigs as compared to pigs left with the sow. As might be expected, it is more difficult to prevent or control scours in the small pigs and in the pigs that get little or no colostrum. Further, pigs weaned after 96 hr of age are much easier to raise artificially, however, it is during the first four days that most pigs are lost when left with the sows. It is very clear that careful management is needed if best results are to be attained.

TABLE 1
SURVIVAL, TREATMENT AND PERFORMANCE OF BABY PIGS WEANED AT VARYING TIMES AFTER BIRTH. TRIAL 1.[a]

	Age weaned, hr.			
	11	50	95	143
No. of pigs	6	6	6	6
No. surviving	6	6	5	6
No. of oral tmts	6.8[b]	3.0[b]	6.3[c]	0
Birth to tmt, hr.	127	133	148	---
Weaning to tmt, hr.	115	83	53	---
Avg. birth wt., g	1296	1279	1336	1365
Avg. weaned wt., g	1380	1567	1898	2295
Avg. final wt., g[d]	5400	5990	5720	5630
Avg. daily gain, g[e]	193	221	206	200
Avg. daily gain, g[f]	---	229	221	218

[a]Hand-fed fortified cow's milk for 12.3 days and then machine-fed Soweana sow milk replacer.
[b]Five of six treated.
[c]Four of six treated-includes one pig that died.
[d]Average age of pigs was 21.3 days.
[e]From birth.
[f]From weaning.

TABLE 2
SURVIVAL, TREATMENTS AND PERFORMANCE OF BABY PIGS WEANED AT VARYING TIMES AFTER BIRTH. TRIAL 2.[a]

	Age weaned, hr.		
	12	49	97
No. of pigs	8	8	8
No. surviving	5	7	8
No. of oral tmts	6	4.9[b]	3.0[c]
Birth to tmt, hr.	48	86	131
Weaning to tmt, hr.	36	37	34
Avg. birth wt., g	1119	1051	1089
Avg. weaned wt., g	1161	1276	1594
Avg. final wt., g[d]	5400	5490	5810
Avg. daily gain, g[e]	163	169	180
Avg. daily gain, g[f]	---	173	189

[a]Hand-fed fortified cow's milk for 12.3 days and the machine-fed Land-o-Lake lamb replacer.
[b]Seven of eight treated-included one pig that died.
[c]Two of eight not treated and 4 of 8 treated only once.
[d]Average age of pigs was 26.3 days.
[e]From birth.
[f]From weaning.

MANAGEMENT AND NUTRITION OF EARLY WEANED PIGS. 2. EFFECT OF VARYING LEVELS OF FIBER IN THE DIET UPON INCIDENCE OF SCOURS, PERFORMANCE AND SURVIVAL

E. T. Kornegay and J. D. Blaha

Previous trials demonstrated that pigs weaned at 12 hr of age and hand-fed 6 times daily a fortified whole cow's milk could be raised and that they performed equally as well as pigs left on the sow. However, the major problem was the prevention or control of scours which occurred during the first few days after the pigs were taken from the sow. In those trials it was not clear whether the first incidence of scours was related more to time from weaning or to time from farrowing. It was evident that the baby pigs started well and that there was generally no problem in getting 12 hr weaned pigs to drink from a cup.

As the level of fiber in the fortified cow's milk was neglible, it was thought that a little fiber (cellulose) might be beneficial in preventing or controlling scours. The objective of these trials was to evaluate the addition of cellulose to the fortified cow's milk previously used and to a commercial sow milk replacer when fed to pigs weaned at 12 and 96 hr of age.

Procedures

Trial 1. Twenty-four pigs weaned at 12 hours after birth were randomly assigned to one of the following treatments from outcome groups based on time of farrowing. Zero, 2 or 4% fiber (cellulose) was added to the fortified whole cow's milk used in the previous trials. As in the two previous trials, the pigs were hand-fed 6 times daily and the temperature in the cages and the room were kept the same. After 14 days the pigs were switched to a commercial milk replacer and were mechanically fed every 90 minutes.

Trial 2. Twenty-four pigs were weaned at either 12 or 96 hr after birth and placed on one of the following diets: zero or 4% fiber (cellulose) added to the fortified whole cow's milk. Pigs were hand-fed 6 times daily for about 13 days and then machine-fed a commercial calf milk replacer for the remainder of the trial. Other management procedures were the same as in trial 1.

Trial 3. Twenty-four pigs were weaned at either 12 or 96 hr after birth and fed one of the following diets: commercial sow milk replacer or commercial sow milk replacer plus 4% cellulose. These diets were fed for 21 days after which another commercial milk replacer was fed for the remainder of the trial. All diets were mechanically fed for the entire trial. Other management procedures were the same as in previous trials.

Results and Discussion

Trial 1. There were no deaths although several of the pigs had to be treated for scours (table 1). As in previous trials, certain individuals were affected more severely and required more treatments. It appeared that the addition of fiber may have been of some benefit. In this trial, scouring was treated by withholding milk and by dosing with kaopectate and milk of bismuth. Average daily gain was somewhat less than was obtained previously and there appeared to be no major difference between treatments.

Trial 2. Again there were no death losses and only two pigs were treated with Biosol-M. The treated pigs were weaned at 12 hr and were fed the diet containing 4% cellulose. There appeared to be no differences in the average daily gain between either the levels of fiber or the weaning age. Average daily gain in this trial was greater than that in trial 1 and also somewhat greater than obtained in the previous trials.

Trial 3. As in trials 1 and 2 there were no deaths; however, one pig weaned at 12 hr and fed the diet with no added fiber was necropsied on the 20th day of the trial due to very poor performance after the first 7 days. This pig was found to have osteodystrophy which probably is unrelated to treatments. There appeared to be no benefit of the added fiber. It might have been slightly detrimental based on average daily gain and incidence of scours. In this trial average daily gain from birth favored the 96 hr weaned pigs although the difference was small. The overall average daily gain in this trial was slightly less than in trial 2, but greater than in trial 1.

Summary

Results of these trials suggest no benefit from the addition of fiber (cellulose) to either a fortified whole cow's milk diet or a commercial sow milk replacer. This research also demonstrated that pigs weaned at 12 or 96 hr could be successfully raised by hand-feeding 6 times daily or by mechanical feeding 16 times daily using automated equipment. No deaths occurred in these trials, although one poor growing pig was necropsied and found to have osteodystrophy which probably is unrelated to treatments. In two of the three trials incidence of scours was minimal-two pigs in each of these trials. In the other trial, 7 of 8 pigs on each dietary level of fiber were treated one or more times; however, treatment was successful. There were only small differences (in favor of the 96 hr weaned pigs) in incidence of scours and average daily gain between pigs weaned at 12 and 96 hr.

TABLE 1
SURVIVAL, TREATMENTS AND PERFORMANCE OF BABY PIGS WEANED AT 12 HOURS AND FED VARYING LEVELS OF FIBER. TRIAL 1.[a]

	Fiber level, % added		
	0	2	4
No. of pigs	8	8	8
No. surviving	8	8	8
No. of oral tmts	7.7[b]	6.1[b]	6.0[b]
Birth to tmt, hr.	81	77	70
Weaning to tmt, hr.	69	65	58
Avg. birth wt., g	1286	1294	1362
Avg. 21 day wt., g	4286	4418	4490
Avg. daily gain, g[c]	141	147	147

[a]Hand-fed a fortified cow's milk for 14.3 days and then switched to Carnation milk replacer and machine-fed.
[b]One pig in each treatment group accounted for 35, 33 and 43% of treatments, respectively, for the 0, 2 and 4% fiber levels. Without this pig in each group, the average number of treatments were 5.8, 4.8 and 4.0, respectively, for the 0, 2 and 4% fiber levels. Seven of eight were treated in each group.
[c]From birth.

TABLE 2
SURVIVAL, TREATMENT AND PERFORMANCE OF BABY PIGS WEANED AT 12 AND 96 HOURS AFTER BIRTH AND FED DIETS CONTAINING 0 AND 4% FIBER. TRIAL 2.[a]

	Treatments			
Age weaned, hr	12	12	96	96
Fiber level, %	0	4	0	4
No. of pigs	6	6	6	6
No. surviving	6	6	6	6
No. of oral tmts	0	0.33[b]	0	0
Birth to tmt, hr	----	127	----	----
Weaning to tmt, hr	----	115	----	----
Avg birth wt, g	1403	1347	1285	1353
Avg weaned wt, g	1494	1452	1773	1901
Avg final wt, g[c]	6174	5993	5857	5947
Avg daily gain, g[d]	242	236	232	233
Avg daily gain, g[e]	----	----	252	250

[a]Hand-fed fortified cow's milk for 12.7 days and then switched to Wayne Calf-Nip milk replacer and machine-fed.
[b]Two pigs treated--each treated once with Biosol-M.
[c]Average age of pig was 19.7 days.
[d]From birth.
[e]From weaning.

TABLE 3.
SURVIVAL, TREATMENT AND PERFORMANCE OF BABY PIGS WEANED AT 12 AND 96 HOURS AFTER BIRTH AND FED DIETS CONTAINING 0 AND 4% FIBER. TRIAL 3.[a]

	Treatments			
Age weaned, hr	12	12	96	96
Fiber level, %	0	4	0	4
No. of pigs	6	6	6	6
No. surviving	5[b]	6	6	6
No. of oral tmts	0.33[b]	1.67[c]	0	0
Birth to tmt, hr	360	131	----	----
Weaning to tmt, hr	348	119	----	----
Avg birth wt, g	1324	1272	1390	1199
Avg weaned wt, g	1423	1349	1956	1807
Avg final wt, g[d]	5857	5221	6315	5938
Avg daily gain, g[e]	196	171	213	205
Avg daily gain, g[f]	----	----	222	210

[a]Machine-fed Soweana for 21 days and switched to snowballs.
[b]Pig 79-2 was necropsied after 20 days on test due to very poor performance and found to have osteodystrophy. This pig gained no weight after the first 7 days on test. This was the only pig treated and was treated twice with Biosol-M for scours on the 17th day of the test.
[c]Two pigs were treated (79-9 and 77-8). Pig 79-9 was treated twice and pig 77-8 was treated 8 times.
[d]Average age of pigs was 23.1 days.
[e]From birth.
[f]From weaning.

MANAGEMENT AND NUTRITION OF EARLY WEANED PIGS. 3. A COMPARISON BETWEEN MACHINE-FED AND HAND-FED PIGS

J. D. Blaha and E. T. Kornegay

Early weaned baby pigs can be raised away from the sow. Whether the method used is a mechanical feeding device or hand feeding in simple cages, careful attention must be paid to sanitation, nutrition, management, disease prevention and treatment and all other conditions related to the welfare of the baby pig. It has been suggested that a simple hand feeding system where pigs are housed in wire cages and hand-fed three times daily ad libitum can be just as successful as a mechanical feeding system and that labor requirement is minimal in such a system. Also the capital outlay would also be much less.

The objectives of this study were: 1) to determine the amount of labor required for two systems of raising early weaned pigs-inexpensive wire cages and feeders with pigs hand-fed three times daily and a somewhat more expensive mechanical feeding system sometimes referred to as an artificial sow, and 2) to compare rate of gain, feed conversion, incidence of scours and survival rate of the pigs raised in the two systems.

Experimental Procedure

A total of 64 pigs from the University herd were used in two trials. Pigs were taken from the sow at birth and placed in a heated box. Upon completion of parturition the entire litter was weighed and returned to the sow and allowed to nurse for approximately 12 hours. The pigs to be used were then reweighed to determine weight gain or loss. Four average sized pigs from each litter were randomly selected and placed on one of two treatments: machine-fed or hand-fed. All pigs were fed a commercial sow milk replacer. However, during the first seven days an equal mixture of the sow milk replacer and freeze-dried cow's colostrum were fed to one half of the pigs on each treatment. This data will be reported at a later time.

Milk was withheld for approximately four hours after the pigs were removed from the sow. Hand-fed pigs were fed three times daily and machine-fed pigs were fed 16 times daily. Every effort was made to equalize the intake on all treatments so that intake would not be a factor in the pig performance.

All pigs were housed in an isolated room with a positive pressure heating-cooling and ventilating system. The system was designed for complete periodic changes of air through a bacterialogical filter with a small amount of outside air (fresh air) being continually introduced. The humidity was held at 40 to 50 percent. Prior to use, the room and all equipment were cleaned with a high pressure washer and fumigated with a formaldehyde-potassium permanganate mixture for 24 hours.

In trial 1 the room temperature was held at 70° F. Small heaters were placed on one end of the cages with thermostats set at 100° F. This allowed the pig to select the most suitable temperature for his individual needs. As the trial progressed, cage temperature was lowered. During the last week of the trial, heaters were not used, and the room temperature was increased to 75° F to adjust pigs to an even room temperature similar to that of the pig nursery where the pigs would be housed after completion of this trial.

In trial 2, initial room temperature was 98° F and was held at this point until the youngest pig was approximately 3 days old. The temperature was then decreased approximately 2° every 3 days until 75° F was reached and it was held at this point for the duration of the trial.

The machine-fed pigs were placed in the mechanical feeding unit consisting of an automatic feeding device that delivers pre set amounts of the dried milk diets which is mixed with water prior to feeding. Pigs are individually fed in a small plastic cup. The feed cups and feed mixers were changed daily and washed in an automatic dish washer. Each pig was housed in an individual 1' x 2' wire cage with an expanded aluminum flooring. The unit has pans under the cage for the collection of feces and urine. A small amount of water was kept in each pan to eliminate odor and the pans were emptied and cleaned daily.

The hand-fed pigs were housed in simple wire cages with expanded aluminum flooring. Each cage contained 4 sq ft and housed two pigs. The pigs were fed in gravity flow fountains which were hand washed with hot water and soap prior to each feeding. Collection pans were used under cages for the collection of feces and urine. A small amount of water was kept in each pan to eliminate odor and the pans were emptied and cleaned daily.

Results

In trials 1 and 2 more time was required to feed and care for the hand-fed pigs (table 1). For both trials, machine-fed pigs required 65.2 minutes as compared to 164.2 minutes for hand-fed pigs. The addition of a dish washer to clean the feeders would possibly cut the time for the hand-fed pigs. Possibly as little as half the time would be needed. However, the addition of automatic equipment would increase the investment.

Overall pig performance favors the machine-fed pigs in both trials (table 2). Average daily gain was greater ($P < .05$) for the machine-fed pigs as compared to hand-fed pigs with no difference in feed consumption between the two groups. The feed gain ratio was significantly different ($P < .05$) in favor of the machine-fed pigs. The incidence of scours was greater in trial 1 than in trial 2.

The survival rate of the machine-fed pigs was 91% and 73% for the hand-fed pigs. A survival rate of 73% is no better than can be obtained on the sow and is unacceptable. The survival rate of the machine-fed pigs would be acceptable, but allows room for improvement.

Summary

From these trials it is evident that the machine-fed pigs were superior in all aspects tested when compared to the hand-fed pigs. The machine-fed pigs had a large gain, took less feed per unit of gain and had a higher survival rate. However, the initial cost of a mechanical feeding system would be higher than the cost of a hand-feeding system.

TABLE 1
SUMMARY OF TIME REQUIRED FOR EACH SYSTEM

	Trial 1		Trial 2	
Item	MF	HF	MF	HF
Total time, min.	890	1734	1131	1880
No. of pigs raised	13	11	18	11
Avg. time per pig raised, min.	68.5	157.6	62.8	170.9
Avg. days in cage	26	26	27	29

TABLE 2
SURVIVAL, TREATMENT AND PERFORMANCE OF EARLY WEANED (12 HR) PIG MACHINE-FED OR HAND-FED

	Trial 1		Trial 2	
Item	MF	HF	MF	HF
No. of pigs	16	14	18	16
No. surviving	12	11	18	11
No. of oral treatments	33[a]	36[b]	2[c]	19[d]
Avg. days in cage	26	26	27	29
Avg. no. of oral treatments	2.3	2.6	.13	1.19
Avg. birth wt, g	1041	1122	1033	1097
Avg. wean wt, g	1076	1200	1086	1153
Avg. brith to wean gain, g	34	78	53	56
Avg. gain in cage, g	5035	3771	4602	4269
Avg. daily gain in cage, g	193	145	169	148
Avg. daily consumption, g	213	217	166	163
Gain per g of feed, g[e]	.90[f]	.67[g]	1.01[f]	.90[g]

[a] One pig, 39-11, died before any treatments.
[b] One pig did not receive any treatment.
[c] Only one pig treated, very mild diarrhea.
[d] Six pigs treated, two died. Three not treated died.
[e] On a dry matter basis.
[f,g] Means on same line within trial with different superscript letters are significantly ($P < .05$) different.

EFFECT OF TWO LEVELS OF DIETARY ZINC ON REPRODUCTIVE PERFORMANCE OF SOWS DURING FIVE PARITIES.

J. D. Hedges, H. R. Thomas and E. T. Kornegay[1]

The importance of zinc as a dietary component was discovered as early as 1934, when it was found to be a dietary essential for rats. In 1955, it was shown that zinc could prevent parakeratosis in swine. Although the deficiency signs manifested are somewhat species dependent, there are several common features that can be defined as typical of zinc deficiency. In order of frequency these are: 1) lesions of the skin, 2) abnormalities of the skeleton, and 3) defects in the reproductive organs and poor reproductive performance. In all species growth rate is depressed but this is directly related to loss in appetite and decreased food intake.

Considerable research has been conducted with the growing pig to determine the zinc requirement. However, very little data exists on the level of dietary zinc required by the sow for normal reproduction and growth. The work that does exist is based on feeding various dietary zinc levels in combination with higher than normal dietary calcium levels. The sow zinc work to date has been conducted for one to two parities only.

The purpose of this study was to evaluate the dietary zinc requirement of gestating-lactating sows housed in confinement and kept for five parities. A low nonsupplemented level (33 ppm) was compared to a normally recommended (supplemented) level (83 ppm).

Experimental Procedure

Seventy-three crossbred gilts were randomly assigned to outcome groups based on breeding dates to three approximately equal replications and assigned treatments in a 2 x 2 factorial experiment. The treatments were low zinc (33 ppm) or high zinc (83 ppm) and group or individual feeding during gestation. Group fed sows were housed on totally slotted floors and the individual fed sows were housed on partially slotted floors.

A corn-soybean meal ration containing 15% crude protein was fed with either 33 ppm zinc or 83 ppm zinc (50 ppm added as zinc sulfate). The calcium level of this ration was 0.83% and the phosphorus level was 0.55 percent. The ration was fed at the rate of 4 lbs/day/head until the 105th day of gestation at which time the daily feed intake was increased to 7 lbs and remained at this level until parturition. After parturition the daily feed intake was increased gradually so that by the 7th day after farrowing the sows were receiving 1 lb of ration for each suckling pig with a minimum daily allowance of 6 lb per sow. All sows irrespective of treatment were farrowed in the same farrowing house. A 3 sow-group multiple farrowing schedule was followed with each sow group cycling about every 150 days.

[1]Appreciation is expressed to the Virginia Pork Industry Commission for financial support.

The following parameters were used: mating, conception and farrowing rate; number of pigs farrowed and weaned; weight of pigs at birth and at weaning. The zinc content of the following tissues was determined: sow serum, sow hair, pig testes and pig coccygeal (tail bone). Sow blood samples were taken from the anterior vena cova and hair samples were taken from the back. The sow samples and baby pig samples were taken within one week of farrowing. At the conclusion of the fourth and fifth parities one pig from each litter was randomly chosen for sacrifice. The following tissues were taken from this pig for zinc analysis: serum, liver, spleen, kidney, bone and skin.

Results

The total number of litters produced favored the high zinc fed sows, 143 total litters vs. 123 for the low zinc fed sows (table 1). The number of live pigs born ($P < .01$), stillborn ($P < .05$) and total pigs born ($P < .01$) were effected only by lactation. Neither the number of mummies nor the average birth weight of the piglets were effected by either treatment.

The number of pigs weaned was not different among treatments (table 2). The average weaning weight was significantly ($P < .01$) effected by a lactation times nutrition interaction. In lactation one the low zinc fed sows had the heaviest weaning weight, however, for the subsequent weaning, except lactation four, the weaning weights were heaviest for the high zinc fed sows. The total weaned weight was effected both by lactation ($P < .01$) and a management times nutrition interaction ($P < .05$). The group fed sows produced the heaviest total weaned weight when fed high zinc and the individual fed sows produced the heaviest weaned weights when fed low zinc.

Serum levels were increased with succeeding lactations ($P < .01$) and by feeding high dietary zinc ($P < .01$). Sow hair, pig testes and coccygeal bone were not effected by nutrition, although there was a lactation ($P < .01$) effect on zinc in the testes and coccygeal bone.

The results of the zinc analyses of the tissues taken from the pigs sacrificed at the fourth and fifth parities showed the zinc content of the liver and bone tissues to be significantly ($P < .01$) increased by feeding supplemental zinc to the sows (table 3).

Summary

There was very little difference in the breeding and reproductive data between the low or high zinc fed sows. There was however significantly less zinc stored in the liver and bone of the pigs born from sows fed low zinc. Based on this data and the results of a follow up study to measure growth rate of the progeny of these sows it is evident that 33 ppm zinc does not meet the sows need for zinc. These sows were unable to produce offspring that had adequate zinc storage at birth.

TABLE 1
EFFECT OF DIETARY ZINC AND MANAGEMENT ON THE NUMBER OF LITTERS PRODUCED AT EACH PARITY.

Criteria	Zinc, ppm 33	83	Management Group	Individual
No. started	35	38	36	37
No. farrowing:				
One litter	35	38	36	37
Two litters	27	32	32	27
Three litters	25	29	28	26
Four litters	21	28	24	25
Five litters	15	16	12	19
Total litters farrowed	123	143	132	134

TABLE 2
FARROWING AND WEANING PERFORMANCE, SOW SERUM AND HAIR ZINC CONTENT AND BABY PIG TESTES AND COCCYGEAL ZINC CONTENT OF SOW FED TWO DIETARY ZINC LEVELS. SUMMARY OF FIVE PARITIES.

	Treatments								
	Lactations					Zn level		Management	
Criteria	1	2	3	4	5	Low	High	Ind.	Grp.
Farrowing data									
Avg no. of sows	73	59	54	49	31	123	143	132	134
No. live pigs born[a]	8.5	8.9	9.8	11.6	11.8	9.8	9.8	10.1	9.4
No. stillborn[b]	0.26	0.45	0.60	0.74	0.44	0.48	0.47	0.45	0.50
No. mummies	0.06	0.18	0.05	0.26	0.12	0.13	0.12	0.18	0.08
No. total pigs born[a]	8.8	9.5	10.5	12.5	12.1	12.4	10.3	10.6	10.0
Avg birth wt., lb	3.17	3.19	3.39	3.39	3.23	3.26	3.28	3.26	3.26
Weaning data									
No. weaned	7.6	7.6	8.3	7.7	8.8	7.9	8.0	8.0	7.9
Avg weaned wt., lb[c]	15.18	15.14	16.32	15.53	14.76	15.29	15.53	15.18	15.64
Total weaned wt., lb[a,d]	115.9	112.6	130.6	119.9	130.0	117.4	123.4	120.5	120.7
Sow serum zinc, ug/100 ml[a,e]	91	102	114	108	146	97	112	102	107
Sow hair zinc, ppm	205.9	209.8	211.5	196.6	207.6	201.2	211.4	206	206
Pig testes zinc, ppm[a]	79.6	79.4	71.6	63.8	61.8	71.8	73.8	72.2	73.5
Pig coccygeal zinc, ppm[a]	86.8	94.8	78.7	74.4	78.1	82.0	85.5	83.4	84.3

[a]Significant ($P < .01$) Lactation effect.

[b]Significant ($P < .05$) Lactation effect.

[c]Significant ($P < .01$) Lactation-nutrition interaction.

[d]Significant ($P < .05$) Management-nutrition interaction.

[e]Significant ($P < .01$) Nutrition effect.

TABLE 3
LIVER, SPLEEN, KIDNEY, BONE, SKIN TISSUE AND SERUM ZINC CONTENT OF NEW BORN PIGS FROM SOWS FED 33 OR 83 PPM DIETARY ZINC FOR FOUR AND FIVE PARITIES. SUMMARIZED BY MAIN EFFECTS[a]

	Sow Zinc, ppm		Sow Management	
Criteria	33	83	Group	Individual
Liver, ppm[b,c]	153.4	252.1	238.0	183.4
Spleen, ppm	130.7	140.6	142.6	130.4
Kidney, ppm	90.6	94.8	92.2	93.1
Bone, ppm[b,c]	139.4	160.8	156.8	146.9
Skin tissue, ppm	71.2	72.8	71.7	72.5
Serum, ug/100 ml	132.7	135.6	135.6	133.2

[a]All tissue on dry basis except serum.

[b]Significant ($P < .01$) Zinc effect.

[c]Significant ($P < .05$) Group effect.

THE EFFECT OF DIETARY ZINC, CALCIUM AND THE PREVIOUS ZINC NUTRITION OF THE SOW ON GROWTH OF PROGENY.

J. D. Hedges, H. R. Thomas and E. T. Kornegay[1]

The need for zinc in the rations of growing-finishing hogs has been well established. It was discovered in 1955 that zinc prevented parakeratosis in swine. Since that time considerable research has been conducted to determine the zinc requirement for the growing hog. Several factors effect the zinc requirement. Sex is important. Males require a higher level of zinc than females. Other dietary ingredients such as high dietary calcium or phytic acid increase the zinc requirement. Certain amino acids and peptides, as well as synthetic chelating agents such as EDTA increase absorption under some conditions. The level of dietary zinc presently fed to meet the requirement of all classes of swine is 50 ppm. Very little work has been conducted to determine the effect of the zinc nutrition of the sow on the growth rate of the progeny.

This work was undertaken to determine the growth response of progeny, from sows fed low or high dietary zinc, when fed various zinc and calcium levels.

Experimental Procedure

The pigs were weaned as close to 4 weeks of age as possible and were randomly allotted to eight dietary treatments from weight outcome groups within sex with the condition that the nutrition of the dam determined the pigs assignment to low sow dietary zinc or high sow dietary zinc treatment. The study was a 2 x 2 x 2 factorial arrangement, with two levels of zinc (33 and 83 ppm), two levels of calcium (0.8 and 1.4% in phase I) and previous zinc nutrition of the sow low (33 ppm) or high (83 ppm) zinc (table 1).

Two feeding trials were conducted with treatments replicated in each trial. A total of 176 pigs with an initial average weight of 22 lbs were used in these studies. The basal ration was corn-soybean meal rations containing 18% crude protein initially, phase I. When the hogs averaged 40 lbs, phase II, the protein was reduced to 16% and the calcium levels were 0.65 and 1.25%, respectively. In phase III, 100 lbs to market, a 14% crude protein ration was fed with calcium levels being 0.5 and 1.0 percent. Feed and water were supplied _ad libitum_ at all times.

Body weight gain and feed consumption was determined for each phase and for overall performance. The hogs were marketed at 200 lbs. Blood and hair samples were taken prior to marketing for mineral analysis.

In study two, data was obtained to determine the effect of zinc on wound healing. A diamond shaped wound 3 x 5 cm was cut into the pigs back, scarlet oil was applied to prevent infection. Measurements of length and width of

[1]Appreciation is expressed to the Virginia Pork Industry Commission for financial support.

the wound were taken weekly to determine if differences in rate of healing occurred. At slaughter the tissue from the wound area was removed for histological examination.

Results

When the data from both trials were combined, the following main effects were obtained (table 2). For phases I and II (initial to 100 lbs) the average daily gain was greater ($P < .05$) for the pigs fed high zinc and for pigs from the high zinc fed sows and less ($P < .01$) for the pigs fed high calcium. Over the entire growing period, initial to market weight, the average daily gain was greater ($P < .05$) for pigs fed the high zinc and less ($P < .01$) for pigs fed the high calcium. Feed intake for phases I and II was lower ($P < .05$) for the pigs fed low dietary zinc and for the pigs from the low zinc fed sows ($P < .05$). Only the low zinc fed pigs continued to have a depressed feed intake over all phases of the growth period. Feed efficiency (higher feed/gain ratio) was depressed ($P < .05$) by the high dietary intake of calcium throughout the entire study.

Pigs fed the high dietary zinc level had higher ($P < .01$) serum zinc levels (table 2). Serum calcium levels were higher ($P < .01$) from pigs fed the high dietary calcium.

Hair zinc content was increased ($P < .01$) for pigs fed the high dietary zinc; whereas, the hair calcium ($P < .05$) and hair copper ($P < .01$) content was lowered by feeding high dietary zinc. The calcium content of the hair was higher ($P < .01$) for pigs fed high dietary calcium; however, the hair iron content was increased ($P < .01$) by feeding high dietary calcium. The hair zinc content was higher ($P < .05$) for pigs from the high zinc fed sows. Hair phosphorus was increased ($P < .05$) by high dietary calcium. High dietary zinc increased wound healing ($P < .05$) but there was no histological difference in the wounds.

Summary

Feeding either low zinc or high calcium rations resulted in poorer feedlot performance throughout the entire growing period. Progeny of sows fed low zinc rations had reduced growth when compared to progeny from sows fed high zinc rations until a weight of 100 lbs was reached at which time there was no difference.

TABLE 1

EXPERIMENTAL TREATMENTS FOR ZINC-CALCIUM STUDY

	Treatments							
	1	2	3	4	5	6	7	8
Zn, Sows, ppm	33	33	33	33	83	83	83	83
Zn, Pigs, ppm	33	33	83	83	33	33	83	83
Ca, %	0.8	1.4	0.8	1.4	0.8	1.4	0.8	1.4

TABLE 2
EFFECT OF DIETARY ZINC, CALCIUM AND PREVIOUS ZINC NUTRITION OF SOW ON FEEDLOT PERFORMANCE, SERUM AND HAIR MINERAL VALUES OF GROWING-FINISHING PIGS.
MAIN EFFECTS

	Main Effects					
	Sow Zn, ppm		Dietary Zn, ppm		Dietary Ca, %	
Criteria	33	83	33	83	0.8	1.4
No. of pigs	88	88	88	88	88	88
Avg initial wt., lb	24.6	23.6	24.1	24.2	24.4	23.9
Avg daily gain, lb						
Initial to 100 lb[a,b,c]	1.33	1.40	1.33	1.40	1.43	1.30
Initial to 200 lb[b,c]	1.48	1.52	1.47	1.54	1.57	1.44
Avg daily feed intake, lb						
Initial to 100 lb[a,b]	3.42	3.64	3.41	3.66	3.61	3.45
Initial to 200 lb[b]	4.76	4.96	4.73	4.99	4.94	4.78
Feed/gain ratio						
Initial to 100 lb[d]	2.58	2.60	2.57	2.61	2.53	2.65
Initial to 200 lb[d]	3.22	3.26	3.23	3.26	3.17	3.32
Serum						
Zn, ug/100 ml[e]	115	119	100	136	122	114
Ca, mg/100 ml[c]	11.0	11.0	11.1	10.9	10.6	11.4
Hair						
Zn, ppm[e,f]	191	190	163	218	194	187
Ca, ppm[a,b,c,g]	522	626	622	528	454	690
P, ppm[d]	259	257	266	250	223	290
Cu, ppm[e]	12.0	12.1	13.0	11.1	12.1	12.0
Fe, ppm[c,h]	32.8	30.4	32.4	31.0	29.4	34.0

[a]Significant ($P < .05$) Sow effect.

[b]Significant ($P < .05$) Zinc effect.

[c]Significant ($P < .01$) Calcium effect.

[d]Significant ($P < .05$) Calcium effect.

[e]Significant ($P < .01$) Zinc effect.

[f]Significant ($P < .01$) Calcium-Zinc interaction.

[g]Significant ($P < .05$) Calcium-Zinc interaction.

[h]Significant ($P < .01$) Sow-Calcium interaction.

FAILURE OF SUPPLEMENTAL ZINC-PROTEINATE, ZINC SULFATE AND METHIONINE TO STIMULATE GROWTH RATE AND FEED EFFICIENCY OF SWINE

E. T. Kornegay and H. R. Thomas[1,2]

Field reports have suggested that a zinc-proteinate complex (ZPC)[3] containing about 9% zinc and 8% methionine added to grower and finisher rations will promote rather large improvements in growth rate and feed efficiency even in the presence of adequate zinc levels; however, results from two trials reported in last year's Livestock Research Report failed to show a significant improvement in gain or feed efficiency when ZPC or zinc sulfate was added to a low or normal zinc swine ration. A trend toward improved feed efficiency was observed in one trial.

The response to added zinc in a ration will depend upon the level of stores in the animal, the level of zinc in the basal ingredients and its availability and the level of calcium and phosphorus in the ration. The NRC (1973) recommended level of dietary zinc is 50 ppm in the presence of recommended levels of calcium and phosphorus. Unpublished data from this research station suggest that this level of zinc is high enough and that the actual requirement may be lower. Supplemental methionine in general has not given a response when added to corn-soybean meal grower and finisher rations.

The trials reported in this study were conducted to further evaluate the addition of ZPC, zinc sulfate or methionine to a basal ration containing recommended levels of zinc.

Procedures

In trial 1, 42 crossbred pigs (2 pens of 7 pigs each per treatment) averaging 29.7 lb initially were randomly assigned to the following dietary treatments: 1) normal zinc (80 ppm Zn), 2) diet 3 plus .1% Z-P (170 ppm Zn), 3) diet 3 plus $ZnSO_4$ (170 ppm Zn). A 16% protein fortified corn-soybean meal ration was fed to 100 lb and a 15% protein ration was fed to market weight.

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[1]Department of Animal Science and Tidewater Research and Continuing Education Center, respectively.

[2]Appreciation is expressed to Dr. C. Y. Kramer for statistical analysis, Jim Hedges for mineral and protein analysis and John Blaha and Fred Barlow for mixing feed and caring for animals.

[3]ZinPro 40 was supplied by Norwich Agricultural Products, Norwich, N.Y. 13815.

In trial 2, 84 crossbred pigs (3 pens of 7 pigs each per treatment) averaging 16.7 lb initially were assigned as in trial 1. At 83.9 lb the three smallest pigs were removed from each pen and the remaining 4 pigs were continued to market weight. Dietary treatments were the same as in trial 1 with an additional dietary treatment (ration 4) in which DL-methionine was added at a level of 80 ppm. This is approximately the amount of methionine supplied by the zinc-proteinate complex. An 18% protein fortified corn-soybean meal ration was fed to 42 lb, and a 16% to 100 pounds. A 15% protein ration was fed to market weight.

In trial 3, 40 crossbred pigs (2 pens of 5 pigs each) averaging 42.7 lb were assigned to the same dietary treatments as in trial 2.

Pigs in all trials were housed in pens with partially slotted floors in an enclosed building with temperature controlled. Feed and water were available at all times. All diets were calculated to contain NRC (1973) levels of calcium and phosphorus. Body weight and feed intake were measured every two weeks. The data were statistically analyzed using the analysis of variance with various treatment comparisons being tested.

Results

The addition of ZPC or zinc sulfate to a corn-soybean meal ration with recommended levels of zinc was ineffective in improving average daily gain, feed intake or feed efficiency (table 2). In the second and third trials where in addition to ZPC and zinc sulfate, DL-methionine was added at a level to equal the methionine in ZPC, average daily gain, feed intake and feed efficiency were not different between treatments. These results agree with our previous report. No problems were experienced with parakeratosis. Higher levels of calcium and phosphorus might have given different results. A response to added DL-methionine was not expected as the rations had adequate choline and research at other universities has been unable to show a response to methionine when added to a similar ration.

Summary

A zinc-proteinate complex was ineffective in promoting improved growth rate and feed efficiency in swine grower and finisher rations with the normally recommended level of 50 ppm zinc added. Further, additional zinc in the form of zinc sulfate did not improve growth rate and feed efficiency. DL-methionine was also ineffective in improving growth rate and feed efficiency when added to these corn-soybean meal rations.

TABLE 1. PERCENTAGE COMPOSITION OF BASAL RATIONS FOR TRIALS 1, 2 AND 3.

Ingredients	Rations[a] 18	16	15
Corn, yellow, grain grnd.	68.96	75.19	79.10
Soybean, seeds, sol-ext'd grnd., mx. 7 fbr.	27.49	21.86	18.30
Limestone, grnd., mn 33% calcium	.65	.65	1.00
Phosphate rock, defluorinated grnd., mx. 1 part fluorine per 100 parts phosphorus	1.45	1.05	.60
Swine trace mineral salt[b]	.50	.50	.50
Vitamin premix[c]	.70	.50	.40
Antibiotic[d]	.25	.25	---
Zinc-proteinate[e]	---	---	---
Zinc sulfate (34% Zn)[f]	---	---	---
DL-methionine[g]	---	---	---
Selenium premix[h]	.025	.025	.025

[a]Eighteen percent fed until pigs weighed 40 lb, 16% fed to 100 lb and 15% fed to market weight.

[b]Contained (%): 0.01 Co, 0.10 Cu, 0.50 Fe, 0.010 I, 0.80 Mn, 1.0 Zn, 0.24 sulfur and 97.3 NaCl.

[c]Supplied (per lb of premix): 0.6 g riboflavin, 3.1 g pantothenic acid, 3.1 g niacin, 4.8 mg vitamin B_{12}, 100 g choline chloride, 600,000 I.U. vitamin A, 100,000 I.U. vitamin D, 1,000 I.U. vitamin E and 150 mg vitamin K (MPB).

[d]In trial 1, 2 and 5 the antibiotic was chlortetracycline (20 g/lb of premix), penicillin (10 g/lb) and sulfathiazole (20 g/lb).

[e]Contained not less than 9% zinc and 8% DL-methionine. Supplied by Norwich Agricultural Products, Norwich, N.Y. 13815. Added at a level of .1 percent.

[f]Added to supply 90 ppm zinc.

[g]Added to supply 80 ppm methionine.

[h]Contained 182 mg of Se per lb of premix.

TABLE 2. AVERAGE DAILY GAIN, FEED INTAKE AND EFFICIENCY OF PIGS FED DIETS WITH ADDED (ZPC) ZINC-PROTEINATE COMPLEX, ZINC SULFATE AND DL-METHIONINE.

	Rations[a]				
	1	2	3	4	
		Normal Zinc			
Criteria	w/o ZPC	with ZPC	with Zinc	with DL-Meth.	Significance
		Trial 1[b]			
Avg daily gain, lb.	1.56	1.61	1.55	---	NS
Avg daily feed intake, lb.	4.23	4.53	4.33	---	NS
Feed/lb gain, lb.	2.73	2.83	2.82	---	NS
		Trial 2, phases 1 and 2[c]			
Avg daily gain, lb.	1.25	1.20	1.18	1.16	NS
Avg daily feed intake, lb.	2.65	2.63	2.42	2.53	NS
Feed/lb gain, lb.	2.11	2.18	2.04	2.16	NS
		Trial 2, phase 3			
Avg daily gain, lb.	1.67	1.88	1.89	1.86	NS
Avg daily feed intake, lb.	5.98	6.01	6.03	5.65	NS
Feed/lb gain, lb.	3.59	3.19	3.19	3.05	NS
		Trial 3[d]			
Avg daily gain, lb.	1.78	1.56	1.67	1.67	NS
Avg daily feed intake, lb.	5.02	4.42	4.65	4.77	NS
Feed/lb gain, lb.	2.81	2.85	2.77	2.87	NS

[a]Calculated zinc levels were 80, 170, 170 and 80 respectively for diets 1 through 4 in trials 1, 2 and 3.

[b]There were 14 pigs per mean (2 pens of 7 pigs each) averaging 29.7 lb initially with a final average weight of 201.3 pounds.

[c]There were 21 pigs per mean (3 pens of 7 pigs each) initially averaging 16.8 lb with a final average weight of 83.9 pounds. At this time the smallest 3 pigs in each pen were removed and the remaining 4 pigs continued to an average final weight of 200.5 pounds.

[d]There were 10 pigs per mean (2 pens of 5 pigs each) initially averaging 42.7 lb with a final average weight of 202.7 pounds.

EVALUATION OF ROASTED CORN AND SOYBEANS FOR SWINE

H. R. Thomas and E. T. Kornegay[1]

A common practice among swine producers is to grind grains and mix with other feedstuffs to make a complete swine ration. Research is constantly needed to find better methods of processing and blending feedstuffs with the prime objective of making more efficient utilization of the ingredients available.

High cost of feed ingredients has prompted researchers to evaluate new methods of processing with the hopes of reducing production cost. Results of limited research conducted to study the effects of cooking feed for livestock are variable. In some studies, there is evidence that roasting grain and whole soybeans (oil included) increases rate of gain while also improving feed efficiency. Other studies have shown little or no advantage for roasting grain or for farm roasting of soybeans for swine.

This study was undertaken to further evaluate roasted corn and whole soybeans (oil included) for swine rations using a commercially available roaster.

Experimental Procedure

Corn and soybeans were roasted with a commercially available gravity fed propane gas fired cooker. The corn and soybeans were roasted at an average temperature of 201° F and 219° F, respectively. Ingredients moved at a constant flow. Heat was increased until a caramel color was obtained. Immediately following the cooking, they were cooled for 24 hours in a commercial corn dryer. After cooling they were ground through a 12 inch hammer mill using a 1/2 inch screen and were stored in bags until required for mixing.

Ninety-six crossbred pigs (4 pens of 6 pigs per treatment) averaging 50.4 lbs were assigned at random to the various treatments from outcome groups based on body weight and sex. Dietary treatments were: 1) normal corn (NC)-soybean meal (SBM), 2) roasted corn (RC)-SBM, 3) NC-roasted soybeans (RSB), 4) RC-RSB. All rations were fortified with minerals, vitamins and antibiotics to meet NRC recommendations and were fed _ad libitum_ (table 1). Protein levels were lowered from 18 to 16% at 40 lb and to 14% at 100 pounds. The study lasted 93 days with the final weights of the pigs being approximately 185 lbs.

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[1]Appreciation is expressed to Mr. Charlie Babb and Mr. Carl Eure for caring for the animals and to Mr. Whitney W. Harris, Richmond, Va. 23223 for roasting the corn and soybeans and to the Virginia Pork Industry Commission for financial support.

Results and Summary

Performance data shown in table 2 is summarized by dietary treatments (rations) and by main treatment effects for phases 1 and 2. Pigs fed rations containing soybean meal as compared to pigs fed rations containing roasted soybeans consistently grew faster ($P < .05$), had a greater ($P < .05$) feed intake for the 100 to 186 lb phase and had a lower ($P < .05$) feed per gain ratio in the 50 to 100 lb phase.

In general there was no overall difference in the performance of pigs fed normal (nonroasted) and roasted corn. In the 100 to 186 lb phase, pigs fed normal corn rations were more efficient ($P < .05$); however, when the entire trial was considered there was no significant difference.

In summary results of this study suggest that there is no advantage for the roasting of normal corn when fed to growing and finishing pigs and that the use of roasted soybeans rather than soybean meal resulted in reduced feedlot performance. The latter finding is not consistent with reports in the literature and suggest that cooking or quality of soybeans may have been inferior in this study.

TABLE 1
PERCENTAGE COMPOSITION OF RATIONS-MAJOR COMPONENTS

	Rations[a]			
Ingredients	NC + SBM	RC + SBM	NC + RSB	RC + RSB
		18% CP, initial to 40 lb		
Normal Corn	72.18	--	64.57	--
Roasted Corn	--	72.18	--	64.57
Soybean Meal	24.47	24.47	--	--
Roasted Soybeans	--	--	32.08	32.08
		16% CP, 40 to 100 lb		
Normal Corn	77.26	--	71.19	--
Roasted Corn	--	77.26	--	71.19
Soybean Meal	19.44	19.44	--	--
Roasted Soybeans	--	--	25.51	25.51
		14% CP, 100 lb to market		
Normal Corn	83.68	--	79.34	--
Roasted Corn	--	83.68	--	79.34
Soybean Meal	13.87	13.87	--	--
Roasted Soybeans	--	--	18.21	18.21

[a]All rations fortified with NRC recommended minerals, vitamins and antibiotics to make 100 percent.

TABLE 2
AVERAGE DAILY GAIN, FEED INTAKE AND FEED PER GAIN OF GROWING-FINISHING PIGS FED NORMAL AND ROASTED CORN AND SOYBEAN MEAL AND ROASTED SOYBEANS.

	Rations				Main Effects			
					Protein		Corn	
Item	NC & SBM	RC & SBM	NC & RSB	RC & RSB	SBM	RSB	NC	RC
No. of pigs	24[a]	24	24	24	48	48	48	48
Avg initial wt., lb.[b]	50.4	50.4	50.7	50.2	50.4	50.4	50.5	50.3
Avg daily gain, lb.								
Phase 1 (50 to 100 lb)	1.51	1.59	1.42	1.45	1.55[c]	1.43	1.47	1.52
Phase 2 (100 to 186 lb)	1.53	1.56	1.38	1.38	1.54[c]	1.38	1.45	1.48
0-95 days	1.52	1.58	1.40	1.42	1.54[c]	1.41	1.46	1.50
Avg daily feed intake, lb.								
Phase 1 (50 to 100 lb)	3.93	4.03	3.85	3.90	3.98	3.87	3.89	3.96
Phase 2 (100 to 186 lb)	4.75	5.30	4.41	4.58	5.02[c]	4.49	4.58	4.93
0-95 days	4.45	4.81	4.20	4.31	4.63[c]	4.26	4.32	4.56
Feed/gain								
Phase 1 (50 to 100 lb)	2.60	2.52	2.70	2.70	2.56[d]	2.70	2.65	2.61
Phase 2 (100 to 186 lb)	3.12	3.42	3.19	3.30	3.27	3.24	3.16[e]	3.36
0-95 days	2.93	3.04	3.00	3.05	2.99	3.02	2.96	3.04
Avg final wt., lb.								
Phase 1 (to 100 lb)	103.5	107.0	103.1	101.5	105.3	102.3	103.3	104.3
0-95 days[f]	190.0	192.2	181.3	183.9	191.1[c]	182.6	185.6	188.0

[a] Four pens of 6 pigs each per treatment.

[b] The average initial weight was 62.2, 54.0, 47.4 and 38.3 lb, respectively, for replications 1 through 4.

[c] Significantly ($P < .05$) larger than means for RSB.

[d] Significantly ($P < .05$) less than means for RSB.

[e] Significantly ($P < .05$) less than means for RC.

[f] The average final weight was 197.9, 195.9, 185.4 and 168.0, respectively, for replications 1 through 4.

AMINO ACID AND PROTEIN EVALUATION OF COMMERCIALLY GROWN OPAQUE-2 AND NORMAL CORNS. TWO YEAR SUMMARY.

E. T. Kornegay[a], H. R. Thomas and J. D. Hedges

The superior protein quality of opaque-2 (high lysine) corn as compared to normal corn has been shown to be due to its greater content of lysine and tryptophan and to its higher apparent protein digestibility. Variation in lysine content existed among opaque-2 corns tested at the various universities. Results of the survey of commercially grown opaque-2 corn conducted in Virginia in 1973 showed a wide variation in the lysine content and the protein level. The results of three feeding trials with growing pigs using opaque-2 corn grown commercially in Virginia indicated that the lysine content of opaque-2 was as available for growing pigs as the lysine in normal corn and that feedlot performance was directly related to the lysine content of the corn.

The sampling of commercially grown opaque-2 and normal corns was continued for another year to obtain additional information as to their amino acid and proximate composition. For comparison purposes both 1973 and 1974 values will be given.

Procedure

Fifty-eight samples (30 in 1973 and 28 in 1974) of commercially grown opaque-2 corn and twenty-eight samples (10 in 1973 and 18 in 1974) of normal corn were obtained from several locations in Virginia for the determination of the amino acids and protein content. Where possible, opaque-2 and normal corn samples were obtained from the same farm and from similar soil types. Crude proteins were analyzed by the macro kjeldahl methods and amino acids were determined from an acid hydrolysate using ion-exchange chromatography (Technicon TSM).

Results

The lysine content of opaque-2 corn ranged from .30 to .50% with an average of .37% in 1973 and from .29 to .44% with an average of .36% in 1974 (table 1). In normal corn the range was from .20 to .26% with an average of .25% in 1973 and from .23 to .31% with an average of .26% in 1974. All values are expressed on a 90% dry basis.

The protein content of opaque-2 corn ranged from 7.3 to 9.6% with an average of 8.4% in 1973 and from 6.8 to 10.6% with an average of 8.6% in 1974. In normal corn, the range was 7.5 to 9.7% with an average of 8.7% in 1973 and from 7.0 to 10.3% with an average of 8.5% in 1974.

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[a]Appreciation is expressed to the Va. Pork Industry Commission for financial support.

Yields obtained only in 1974 were nonsignificantly lower (6.7%) for opaque-2 corns as compared to normal corn grown on the same farm.

TABLE 1
LYSINE AND PROTEIN CONTENT OF OPAQUE-2 AND NORMAL CORNS GROWN COMMERCIALLY IN VIRGINIA DURING 1973 AND 1974 (90% DM BASIS).

Type of corn and year	No. of samples	Lysine	Protein	Yields
		%	%	bu/acre
Opaque-2				
1973	30	.37	8.4	--
Range		.30 to .50	7.3 to 9.6	--
1974	28	.36	8.6	143
Range		.29 to .44	6.8 to 10.6	96 to 192
Weighted Avg.	58	.37	8.5	--
Normal				
1973	10	.25	8.7	--
Range		.20 to .26	7.5 to 9.7	--
1974	18	.26	8.5	152
Range		.23 to .31	7.0 to 10.3	102 to 216
Weighted Avg.	28	.26	8.6	--

There was a positive linear regression between protein and lysine content of opaque-2 corn with a derived prediction equation of $Y = .044X - .002$ ($r = .59$; $P < .01$) in 1973 and $Y = .032X + .084$ ($r = .80$; $P < .005$) in 1974; Y = % lysine and X = % protein. For the combined years the prediction equation was: $Y = .037X + .051$ ($r = .63$; $P < .005$). The relationship between protein and lysine in this study is in close agreement with that reported by Baker and others at the University of Illinois, $Y = .037X + .002$ ($r = .62$; $P < .01$), and less than found by Nordstrom at the University of Minnesota. The prediction equation calculated by the authors from the data reported by Nordstrom is: $Y = .061X - .162$ ($r = .95$; $P < .005$). Nordstrom also reported much higher protein (9.79%) and lysine (.432%) for 15 samples of opaque-2 corn grown commercially in Minnesota in 1971.

The relationship between protein and lysine in normal corn was not nearly so great. In 1973, the regression was nonsignificant and in 1974 the regression was significant only at the 5% level. For the combined years it was non-significant, which agrees with calculations made from protein and lysine content of normal corn reported by Nordstrom.

The lysine and protein content of opaque-2 corn was similar for the two years and are in close agreement with values reported by Baker for corn obtained in Illinois in 1972 but are lower than values reported by other researchers.

Components of the proximate analysis and all amino acids are shown in table 2. Crude protein, crude fiber and NFE levels were not different between opaque-2 and normal corn and between 1973 and 1974. Ether extract content of opaque-2 corn was higher than that of normal corn in 1973 with only a trend in 1974. Ash was higher for opaque-2 corn for both years.

In addition to lysine, aspartic acid, histidine and arginine were higher in opaque-2 corn than in normal corn for both years. Levels of threonine, valine and cystine were not different. Levels of serine, glutamic acid, proline, glycine, alanine, methionine, isoleucine, leucine, tyrosine and phenylalanine were lower in opaque-2 as compared to normal corns.

Summary

1. Both opaque-2 and normal corns are quite variable in their protein and lysine content.

2. Protein levels were not different between opaque-2 and normal corns.

3. Lysine ranged from .29 to .50% with an average of .37% for opaque-2 corn. For normal corn the range was .20 to .31% with an average of .26% (90% dry basis).

4. Correlation analyses were made between protein and lysine content for normal and opaque-2 corn. This measure is based upon 1.0 as a perfect relationship and 0.0 as a complete lack of a relationship. For normal corn the correlation (or relationship) was low (0.35) and statistically nonsignificant which means that the lysine content of normal corn was relatively constant no matter what the protein level.

5. However, for opaque-2 corn the relationship between lysine content and protein level was good (0.63) and was highly significant which means that for a majority of the samples of opaque-2 corn a high protein level was indicative of a high lysine content. The relationship was stronger in 1974 than in 1973.

6. Due to the variation in the lysine content of opaque-2 corn, for best ration formulation an assay for the lysine content should be made. This way optimum performance of the pig can be maintained and maximum value of the corn can be obtained.

7. In lieu of an actual lysine assay, the next best thing would be to get a protein determination and calculate the lysine content by using the following prediction equation derived from the correlation analysis mentioned above: Y (% lysine) = .037 X (% protein) + .051. For example if protein was found to be 9.7%, then the estimated (or predicted) lysine content would be .037 times 9.7% plus .051 or 0.41% lysine.

TABLE 2
PROXIMATE AND AMINO ACIDS, COMPOSITION OF OPAQUE-2 AND NORMAL CORNS

Item	Corn[a] Opaque-2[b] 1973	1974	Normal[c] 1973	1974	Significance 1973	1974
	Proximate Components					
Crude protein, %	8.37	8.61	8.72	8.52	NS	NS
Ether extract, %	4.09	3.71	3.67	3.56	**	NS
Crude fiber, %	4.17	3.93	3.86	3.72	NS	NS
Ash, %	1.37	1.35	1.24	1.26	**	*
NFE, %	71.97	72.40	72.51	72.95	NS	NS
	Amino Acids, %					
Aspartic acid	.64	.75	.55	.62	***	**
Threonine	.32	.32	.33	.31	NS	NS
Serine	.37	.36	.40	.37	**	**
Glutamic acid	1.20	1.42	1.45	1.57	***	**
Proline	.63	.69	.73	.75	***	**
Glycine	.39	.39	.32	.32	***	**
Alanine	.49	.53	.58	.60	***	**
Valine	.41	.42	.41	.38	NS	NS
Cystine	.33	.33	.32	.29	NS	NS
Methionine	.16	.16	.20	.18	***	**
Isoleucine	.26	.27	.29	.28	**	**
Leucine	.66	.75	.92	.94	***	**
Tyrosine	.26	.27	.30	.29	***	**
Ph nylalanine	.34	.36	.41	.39	***	**
Lysine	.37	.36	.25	.27	***	**
Histidine	.28	.29	.24	.25	***	**
Arginine	.54	.52	.43	.40	***	**

[a]All means expressed on 90% dry basis.

[b]Mean of 30 and 26, respectively, for 1973 and 1974.

[c]Mean of 10 and 18, respectively, for 1973 and 1974.

*P < .05 **P < .01 ***P < .001.

EVALUATION OF THE AMINO ACID CONTENT AND THE PROXIMATE COMPOSITION OF SEVERAL VARIETIES AND GRADES OF PEANUTS

E. T. Kornegay, H. R. Thomas[1], R. W. Mozingo[1], T. A. Coffelt[1] and J. D. Hedges[2]

The value of peanuts as a high protein feed for humans and animals has been known for many years. However, the use of peanut meal as the sole source of supplemental protein for most feed grains is restricted due to its low quality protein, primarily a deficiency of the amino acid lysine. The objective of this study was to determine the amino acid content and proximate composition of five varieties and six grades of each variety so that any varieties or grades with superior amino acid content could be located.

Procedures

Five varieties and six grades of each variety were supplied by the Tidewater Research and Continuing Education Center. The samples were ground in a Waring blender, mixed and dried. A representative portion of each sample was taken for amino acid analysis and was prepared by removing the oil, using the Baily-Walker ether extraction apparatus. It was then ground through a micro Wiley mill with a 40 mesh screen. One tenth of a gram of dry-fat free meal was weighed accurately into the hydrolyzate tubes, ten ml of 6N HCl was added to this, which was then sealed under nitrogen and placed in an oven at 100° C for 36 hours. Upon removal from the oven the samples were cooled and filtered. Two mls of the filtrate was put under vacuum with NaOH flocks and taken to dryness. The sample was reconstituted by the addition of 4 mls of pH 2.0 citrate buffer. The sample was then placed on a Technicon TSM Amino Acid analyzer at a level to give 0.5-1.0 mg of protein. Tryptophan was not determined. Nitrogen was determined by the macro kjeldahl method. Nitrogen was converted to protein by using the conversion factor of 6.25. Ether extract was determined by extracting a 2 gm sample of the original mixed and dried preparation overnight using the Baily-Walker extraction apparatus. Crude fiber was determined by the method of Whitehouse. Ash was determined by ashing a 2.0 gm sample for 2 hours at 600° C. Moisture was determined by drying a 2.0 gm sample at 100° C for 24 hours.

Results

The proximate components of the peanuts by varieties and grades are shown in table 1. In all varieties the oil stock grade was lowest in crude protein (N x 6.25) and ether extract, and highest in ash. The ELK grades seemed to be highest in ether extractable material. The values in table 1 can be converted to a dry-fat free basis by dividing by the dry matter and ether extract.

Amino acids by varieties and grades are presented in table 2. Although the differences among varieties appear small, it seems that varieties 4 and 5 (61 R and 72 R) are higher in lysine than variety 2 (NC 17) with varieties 1 and 3 (Florigiant and NC-Fla 14) being intermediate.

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[1]Tidewater Research and Continuing Education Center.
[2]Appreciation is expressed to the Virginia Pork Industry Commission for financial support.

TABLE 1
PROXIMATE COMPONENTS OF FIVE VARIETIES AND SIX GRADES OF PEANUTS[a]

Components and Variety[c]	Grades[b] 1	2	3	4	5	6
Dry Matter, %						
1	94.19	93.86	94.70	92.86	91.35	93.56
2	94.11	93.56	93.02	93.79	91.82	93.78
3	95.19	93.61	94.45	94.81	91.86	93.76
4	94.87	94.83	94.62	93.93	92.40	94.98
5	94.86	94.76	94.67	94.57	92.92	94.77
Nitrogen, %						
1	4.60	4.87	5.08	4.80	4.61	4.80
2	4.79	4.85	4.77	4.65	4.44	4.75
3	4.83	4.92	5.09	4.73	4.53	4.73
4	4.86	4.80	4.76	5.09	4.59	4.79
5	4.87	4.98	4.84	4.84	4.58	4.91
Crude protein (N x 6.25)						
1	28.75	30.44	31.75	30.00	28.76	30.00
2	29.99	30.31	29.81	29.06	27.76	29.69
3	30.19	30.75	31.81	29.56	28.26	29.56
4	30.32	30.00	29.75	31.81	28.69	29.94
5	30.44	31.12	30.25	30.25	28.63	30.79
Ash, %						
1	4.33	4.41	4.46	4.49	5.82	4.36
2	4.02	3.91	3.92	4.32	6.80	4.00
3	3.95	3.98	4.26	4.29	6.26	3.89
4	3.96	4.04	4.33	4.85	6.20	4.15
5	4.23	4.28	4.99	4.43	6.05	4.28
Ether Extract, %						
1	50.15	49.06	45.42	43.53	34.86	48.09
2	48.70	47.17	43.64	47.55	36.16	49.81
3	51.78	49.32	46.58	49.50	39.35	50.98
4	47.58	46.41	43.81	41.55	31.33	46.87
5	48.63	46.41	42.39	45.37	33.49	47.18
Crude Fiber, %						
1	10.50	8.00	6.28	8.61	7.57	8.50
2	8.05	6.86	6.52	7.47	5.86	6.61
3	9.00	9.10	7.11	7.33	6.93	7.53
4	8.80	7.65	6.28	6.72	7.00	7.00
5	7.64	6.89	5.60	5.68	5.95	6.97

[a]Expressed on an as received basis (wet ground whole peanuts)

[b]Code, 1=ELK, 2=medium, 3=No. 1, 4=No. 2, 5=Oil stock and 6=all kernels

[c]Code, 1=Florigiant, 2=NC 17, 3=NC-Fla 14, 4=61R, and 5=72R

TABLE 2
AMINO ACID CONTENT OF SEVERAL VARIETIES AND GRADES OF PEANUTS (% OF TOTAL WEIGHT)[a]

Amino Acid and Variety[c]	Grades[b] 1	2	3	4	5	6
Aspartic Acid						
1	3.08	3.01	2.31	2.51	2.26	2.48
2	2.54	2.52	2.59	2.56	2.23	2.46
3	3.23	2.73	2.86	2.41	2.56	2.52
4	3.26	2.88	2.85	2.38	2.32	2.80
5	3.25	2.70	2.59	2.47	2.03	2.49
Threonine						
1	.84	.84	.66	.75	.76	.72
2	.75	.76	.80	.78	.72	.74
3	.92	.81	.86	.80	.75	.80
4	.95	.80	.83	.72	.72	.83
5	.94	.78	.77	.74	.65	.76
Serine						
1	1.58	1.46	1.10	1.26	1.04	1.28
2	1.28	1.24	1.24	1.33	1.07	1.22
3	1.59	1.32	1.31	1.27	1.09	1.33
4	1.60	1.33	1.49	1.21	1.06	1.41
5	1.53	1.24	1.35	1.20	1.06	1.30
Glutamic Acid						
1	4.84	4.80	3.41	3.50	3.17	5.23
2	3.83	4.00	3.94	3.75	4.12	3.64
3	4.98	3.96	4.30	5.63	4.34	2.13
4	5.25	4.35	4.20	5.06	4.22	3.98
5	5.20	4.13	3.79	5.31	4.01	2.12
Proline						
1	1.43	1.31	1.16	1.06	1.02	1.12
2	1.38	1.26	1.18	1.30	1.04	1.28
3	1.57	1.44	1.33	1.18	1.04	1.27
4	1.48	1.31	1.26	1.18	1.06	1.15
5	1.41	1.37	1.17	1.12	0.99	1.16
Glycine						
1	1.94	1.79	1.73	1.49	1.33	1.65
2	1.46	1.37	1.38	1.36	1.19	1.42
3	1.78	1.43	1.55	1.42	1.35	1.50
4	1.97	1.69	1.57	1.47	1.40	1.72
5	1.97	1.59	1.43	1.55	1.19	1.58
Alanine						
1	1.26	1.26	1.08	1.08	1.08	1.16
2	1.14	1.15	1.16	1.10	1.01	1.14
3	1.44	1.24	1.22	1.12	1.03	1.19
4	1.39	1.21	1.24	.62	.57	1.21
5	1.32	1.19	1.13	.62	.57	1.15

Table 2 Cont'd.

Amino Acid and Variety	Grades 1	2	3	4	5	6
Valine						
1	1.13	1.13	1.00	.94	.90	1.01
2	1.18	1.13	1.10	1.13	.97	1.10
3	1.39	1.22	1.23	1.16	1.02	1.16
4	1.34	1.17	1.11	1.03	.94	1.21
5	1.29	1.12	.97	1.06	.88	1.09
Cystine						
1	.72	.74	.67	.56	.53	.70
2	.81	.74	.66	.65	.53	.70
3	.79	.70	.75	.67	.55	.70
4	.81	.82	.55	.56	.46	.72
5	.81	.78	.53	.65	.44	.70
Methionine						
1	.37	.37	.36	.34	.32	.39
2	.40	.39	.34	.37	.34	.38
3	.41	.36	.36	.37	.32	.35
4	.41	.35	.36	.33	.32	.37
5	.43	.36	.36	.35	.28	.35
Isoleucine						
1	1.90	1.84	1.54	1.54	1.32	1.58
2	1.73	1.72	1.63	1.63	1.39	1.60
3	1.99	1.80	1.74	1.67	1.38	1.62
4	2.06	1.74	1.69	1.52	1.39	1.77
5	1.98	1.70	1.52	1.57	1.34	1.64
Leucine						
1	2.14	2.09	1.53	1.64	1.40	1.67
2	1.71	1.28	1.74	1.77	1.46	1.73
3	2.21	1.87	1.87	1.71	1.54	1.74
4	2.29	1.93	1.90	1.58	1.41	1.88
5	2.26	1.87	1.71	1.65	1.37	1.71
Tyrosine						
1	1.21	1.21	.91	.94	.83	1.00
2	1.10	1.10	1.09	1.04	.89	1.05
3	1.38	1.27	1.17	1.08	.85	1.23
4	1.36	1.16	1.12	.96	.79	1.13
5	1.33	1.10	1.00	1.02	.73	1.05
Phenylalanine						
1	1.40	1.36	1.19	1.10	.99	1.22
2	1.47	1.31	1.21	1.23	.97	1.39
3	1.57	1.46	1.38	1.20	1.03	1.38
4	1.65	1.39	1.33	1.19	.96	1.46
5	1.59	1.31	1.16	1.24	.90	1.25
Lysine						
1	1.06	1.15	.98	1.08	1.14	1.04
2	.98	1.00	1.05	.98	.97	.95
3	1.13	1.03	1.06	.99	1.02	1.05
4	1.23	1.06	1.12	1.03	1.04	1.12
5	1.23	1.07	1.11	1.03	.97	1.00

Table 2 Cont'd.

Amino Acid and Variety	Grades 1	2	3	4	5	6
Histidine						
1	.79	.83	.60	.62	.64	.64
2	.73	.72	.69	.67	.56	.69
3	.87	.74	.76	.68	.60	.80
4	.90	.76	.69	.64	.55	.76
5	.87	.76	.66	.66	.52	.68
Arginine						
1	4.96	5.58	3.73	4.22	4.91	4.25
2	3.55	3.74	4.45	3.79	3.90	3.40
3	5.01	3.67	4.59	3.96	4.44	3.81
4	4.99	4.70	4.73	4.40	5.17	4.04
5	5.13	4.63	4.39	4.14	4.70	3.79

[a]Expressed on an as received basis (wet ground whole peanuts)

[b]Code, 1=ELK, 2=me um, 3=No. 1, 4=No. 2, 5=Oil stock and 6=all kernels

[c]Code, 1=Florigiant, 2=NC 17, 3=NC-Fla 14, 4=61R, and 5=72R

NUTRITIVE VALUE OF SWINE FECES FOR SWINE

M. R. Holland, E. T. Kornegay and J. D. Hedges[a]

The use of livestock and poultry waste as a feed ingredient offers the potential for salvaging some of the nutrients and for minimizing the waste disposal problem. A considerable amount of research has been done with processing methods and the feeding of broiler litter to ruminants and cattle manure to ruminants. Little research has dealt with the refeeding of swine feces, although, dried swine feces, oxidation ditch liquor, and oxidation ditch mixed liquor have been tested as feed ingredients for swine.

The objectives of this study were to characterize wet and dried swine feces as to its proximate, energy and mineral composition and to determine digestibilities and retention values for the proximate, energy and mineral components.

Procedure

Forty-eight crossbred gilts averaging 275 lb were used in two trials of two replications each. Twelve gilts in each replication were randomly allotted from weight outcome groups to three rations. Stainless steel metabolism cages were used for these trials. The gilts were fed twice daily and an excess of water was placed in the feeding trough after the gilts were allowed one hour to eat.

In the first trial (wet) fresh swine feces were incorporated into the rations at the time of feeding. The three test rations were: 1) basal (15% crude protein fortified corn-soybean meal[b]), 2) basal substituted with 22.90% swine feces, and 3) basal substituted with 33.83% swine feces. The feces were collected from finishing hogs that were housed on slotted floors consuming a similar corn-soybean meal ration. The feces dropped through the slots and were collected off of boards that were 3 ft by 4 ft and sloped 1 inch per foot towards the rear of the pen. The sloped board facilitated the run off of excess urine so that urine contamination could be kept at a low level. The feces were weighed and incorporated into the basal ration at a level based on its estimated dry matter content. Sufficient water was blended into rations to hold dry matter at a constant level.

In the second trial (dry) fresh feces collected in the same manner as previously described was then placed in large pans lined with wire mesh screen at a depth of approximately 1 inch and dried for 24 hours in a forced draft oven at 167° F (75° C). The dried swine feces were then ground through a hammer mill with a 60 mesh (1/4 inch square) screen. The test diets were blended in a horizontal mixer. Dried feces were substituted for the 15% basal corn-soybean ration previously used at levels of 20.50% and 40.71% of the dry matter of the basal rations.

[a]The Virginia Agricultural Foundation supplied partial funding for this research.

[b]Percentage composition of basal ration: ground yellow corn, 78.5; solvent extracted soybean meal (mx 7 fbr.), 18.3; defluorinated phosphate, 1.2; limestone, 1.0; swine trace mineral salt (high zinc), 0.6; VPI vitamin premix, 0.4; and ferrous sulfate, 0.02.

In both trials the gilts were placed in the stainless steel cages for a minimum of five to seven days before adjustment to test rations was begun. The level of feces fed in the test ration was gradually increased over a five day period. When the maximum level was reached the gilts were fed for three days and then a five day total collection was carried out. Feces were collected from the gilts twice daily and the pH of the urine was adjusted as needed to prevent the loss of ammonia. Feces collected from the gilts were dried for twenty-four hours at 140° F (60° C) in a forced air oven at the time of collection and redried in the same manner at the end of the trial.

The feces were then ground through a Wiley Mill equipped with a .039 in (1 mm) screen and mixed thoroughly. Samples were then taken and packed tightly in feed cups to prevent layering or shifting of the particulate matter. Urine was sampled at the end of the trial and frozen until analysis could be performed.

Results and Discussion

There was a wide variation between animals in their acceptance of the feces blended rations with less acceptance of the wet feces blended rations. There were, however, only small differences in the digestibility and utilization of the various nutrients, therefore, the results of the wet and dry trials will be combined for presentation and discussion in this paper.

Ash, crude fiber, ether extract and crude protein content of rations fed was increased as feces were substituted for the basal ration (table 1). Gross energy was about the same and nitrogen free extract (NFE) was lowered as feces was substituted. The concentration of all minerals analyzed was increased as feces were substituted for the basal ration.

The fecal content of crude fiber, ether extract, crude protein, magnesium, copper and zinc increased as the amount of feces substituted was increased (tables 2 and 3). The fecal content of ash, NFE, calcium, phosphorus and potassium tended to be constant. There was a large increase in the amount of feces excreted by the gilts when feces were substituted for the basal ration with no differences in urinary output. The difference in fecal excretion between trials (table 2) reflects primarily the difference in dry matter intake which was greater in the wet trial, although, there was slightly higher digestibility of dry matter in the wet trial as compared to the dry trial (52.59 vs. 43.71%).

The crude fiber, ether extract, NFE and gross energy values were different for feces collected from gilts on the wet trial versus the dry trial. In the case of crude fiber, the difference was due to a lower content (16.25 vs. 20.46%) and higher digestibility (50.48 vs. 31.20%) of crude fiber in the rations of the wet trial as compared to the dry trial. For ether extract, NFE and gross energy the differences are due primarily to differences in the rations fed as the digestion coefficients were not different between trials. There was a difference between the wet and dry trials for the fecal concentrations of calcium, magnesium and zinc which was probably due to a higher level being fed as there was no difference in the digestion coefficients (tables 3 & 6). Phosphorus was the only urinary component that was increased as the level of feces substituted for the basal ration was increased.

The apparent digestibilities of the proximate components, apparent net protein utilization and apparent biological value of the test rations are given in table 4. Digestion coefficients for crude fiber, dry matter, ether extract, crude protein and NFE were all significantly lowered as feces were substituted for the basal ration with predicted values of 40.84, 48.15, 54.11, 60.13 and 45.89%, respectively. The apparent digestibility of crude protein was significantly depressed by the inclusion of feces in the test rations, but net protein utilization and biological values were not significantly affected. The digestible energy, metabolized energy and metabolizable energy corrected for nitrogen retention all decreased significantly as the level of substituted feces was increased (table 5). The predicted values of digestible energy, metabolized energy and metabolizable energy corrected for nitrogen retention for swine feces are all substantially lower than those for the basal corn-soybean meal ration.

Mineral retention and digestibility data given in table 6 show that there was a significant decrease in the percentage of absorbed calcium, phosphorus and potassium as feces were substituted for the basal ration. Retained phosphorus as a percent of intake and as a percent of absorbed phosphorus was also significantly decreased. There was a significant increase in retained magnesium as a percent of absorbed magnesium as feces were substituted with the value for the wet trial being higher.

Summary

Swine feces collected from finishing hogs was fed to 48 crossbred gilts averaging 275 lb body weight in two total collection metabolism trials to characterize wet and dried swine feces as to its proximate, energy and mineral composition and to determine digestibilities and retention values for the proximate, energy and mineral components. One trial was conducted using unprocessed feces (fresh) and another trial was conducted using dried feces.

Fecal content of crude fiber, ether extract, crude protein, magnesium, copper and zinc increased as the amount of feces substituted for the basal ration was increased. The fecal content of ash, NFE, calcium, phosphorus and potassium tended to be constant. Urinary phosphorus was the only urinary component that was significantly increased when feces were substituted for the basal ration. The amount of feces excreted increased as the amount of feces substituted for the basal ration was increased with no differences in urinary output.

Swine feces was found to be of less nutritive value than a basal corn-soybean meal ration, but nutrients were available. Digestion of ash, crude fiber, dry matter, ether extract, crude protein and nitrogen free extract were all significantly reduced when swine feces was substituted for the basal ration. Net proetin utilization and biological value were not significantly changed. There were significant decreases in digestible energy, metabolized energy and metabolizable energy corrected for nitrogen retention as feces were substituted for the basal ration. Absorbed calcium, phosphorus and potassium were significantly decreased as feces were substituted for the basal ration with no changes in absorbed copper and zinc. Retained phosphorus as a percent of gross intake and as a percent of absorbed phosphorus was significantly lowered as feces was substituted for the basal ration. Digestibilities and retention values were similar between the wet and dry trials.

TABLE 1
AVERAGE PROXIMATE, ENERGY AND MINERAL COMPOSITION OF TEST RATIONS AND FECES SUBSTITUTED IN WET AND DRY TRIALS (100% DM BASIS).

Components	Rations			Feces Substituted
	1[a]	2[b]	3[c]	
Ash, %	4.56	6.92	8.58	15.32
Crude Fiber, %	4.88	7.08	8.57	14.78
Ether Extract, %	3.02	4.11	4.88	8.02
Crude Protein, %	16.65	18.19	19.21	23.50
Nitrogen Free Extract, %	70.91	63.71	58.76	38.28
Gross Energy, Kcal/g.	4.41	4.45	4.53	4.57
Calcium, %	.74	1.19	1.49	2.72
Phosphorus, %	.56	.86	1.11	2.13
Magnesium, %	.18	.33	.44	.93
Potassium, %	.72	.85	.95	1.34
Zinc, ppm	82.43	168.41	249.65	530.37
Copper, ppm	8.62	20.32	28.33	62.83

[a]Basal corn-soybean ration.
[b]Feces substituted for 21.74% on DM basis.
[c]Feces substituted for 37.27% on DM basis.

TABLE 2
AVERAGE AMOUNT OF FEED, FECES AND URINE AND PROXIMATE COMPONENTS OF FECES AND URINE FROM GILTS ON TEST RATIONS IN WET AND DRY TRIALS (100% DM BASIS).

Components	Rations			Sig.[a]
	1[b]	2[c]	3[d]	level
	Amounts of Feed, Feces and Urine			
Feed Intake, g/day	1302.25	1352.71	1348.50	
Fecal output, g/day	136.69	268.79	348.12	.0001
Urinary output, l/day	5.43	5.01	4.88	.8378
	Proximate Components and Energy of Feces			
Ash, %	20.51	19.99	20.40	.7304
Crude Fiber, %	15.20	15.73	16.47	.0162
Ether Extract, %	6.45	7.01	6.95	.0128
Crude Protein, %	20.45	19.36	18.37	.0008
Nitrogen Free Extract, %	37.40	37.91	37.82	.8412
Gross Energy, Kcal/g.	4.62	4.70	4.72	.0845

[a]Probability of difference between rations.
[b]Basal corn-soybean ration.
[c]Feces substituted for 21.74% on DM basis.
[d]Feces substituted for 37.27% on DM basis.

TABLE 3

AVERAGE MINERAL COMPONENTS OF FECES AND URINE, AND URINARY NITROGEN AND ENERGY OF URINE AND FECES FROM GILTS ON TEST RATIONS IN WET AND DRY TRIALS (100% DM BASIS).

Components	Rations			Sig.[a]
	1[b]	2[c]	3[d]	level
	Mineral Components of Feces			
Calcium, %	4.39	4.18	4.27	.3486
Phosphorus, %	3.04	2.84	2.97	.3153
Magnesium, %	1.17	1.31	1.34	.0015
Potassium, %	.91	.92	.93	.9687
Copper, ppm	73.93	84.86	92.18	.0004
Zinc, ppm	633.25	745.21	805.25	.0001
	Urinary Components			
Calcium, ppm	78.19	69.59	66.63	.6971
Phosphorus, ppm	79.99	162.60	357.22	.0001
Magnesium, ppm	109.77	162.60	131.03	.1700
Potassium, ppm	1725.94	1880.71	1982.31	.3260
Urinary N, g/l	4.69	5.05	5.13	.8484
Urinary Energy, Kcal/g.[e]	2.05	2.16	2.13	.8081

[a]Probability of difference between rations.
[b]Basal corn-soybean ration.
[c]Feces substituted for 21.74% on DM basis.
[d]Feces substituted for 37.27% on DM basis.
[e]Freeze dried sample.

TABLE 4

AVERAGE APPARENT DIGESTIBILITIES OF PROXIMATE COMPONENTS, NET PROETIN UTILIZATION AND BIOLOGICAL VALUE DETERMINATIONS FOR WET AND DRY TRIALS.

Item	Rations			Predicted[a]	Sig.[b]
	1[c]	2[d]	3[e]		level
Digestibility of:					
Ash, %	52.94	42.27	39.33	31.55	.0015
Crude Fiber, %	67.22	55.03	50.47	40.84	.0001
Dry Matter, %	89.46	80.11	74.34	48.15	.0001
Ether Extract, %	77.02	66.20	64.36	54.11	.0001
Crude Protein, %	86.95	78.76	75.60	60.13	.0001
Nitrogen Free Extract, %	94.43	88.12	83.26	45.89	.0001
Net Protein Utilization, %[f]	31.05	29.26	26.52	22.42	.3636
Biological Value, %[g]	35.75	37.05	35.20	36.79	.9520

[a]Calculated by difference.
[b]Probability of difference between rations.
[c]Basal corn-soybean ration.
[d]Feces substituted for 21.74% on DM basis.
[e]Feces substituted for 37.27% on DM basis.
[f]Apparent net protein utilization equals retained protein as a percent of protein intake.
[g]Apparent biological value equals retained protein as a percent of absorbed protein.

TABLE 5
AVERAGE DIGESTIBLE ENERGY, METABOLIZABLE ENERGY AND METABOLIZABLE ENERGY CORRECTED FOR NITROGEN RETENTION FOR WET AND DRY TRIALS (100% DM BASIS).

Components	Rations			Predicted[a]	Sig.[b]
	1[c]	2[d]	3[e]		level
Energy per gram of Test Ration, Kcal					
Digested	3.92	3.51	3.32	2.24	.0001
Metabolized	3.76	3.33	3.15	2.03	.0001
Metabolized, corrected for Nitrogen Retention	3.67	3.24	3.06	1.92	.0001
Digestible, %	88.96	78.89	73.32	46.65	.0001
Metabolizable, %	85.39	74.88	69.55	41.98	.0001
Metabolizable, corrected for Nitrogen Retention, %	83.30	72.75	67.54	39.92	.0001

[a]Calculated by difference.
[b]Probability of difference between rations.
[c]Basal corn-soybean ration.
[d]Feces substituted for 21.74% on DM basis.
[e]Feces substituted for 37.27% on DM basis.

TABLE 6
AVERAGE MINERAL DIGESTIBILITIES AND RETENTIONS FOR WET AND DRY TRIALS.

Item	Rations			Predicted[a]	Sig.[b]
	1[c]	2[d]	3[e]		level
Absorbed Ca, %	38.62	30.09	27.02	22.19	.0276
Retained Ca, %	34.91	28.11	25.40	21.73	.0788
Retained Ca, % of Ab.	89.36	92.05	92.79	94.52	.2362
Absorbed P, %	42.59	33.99	31.94	27.26	.0361
Retained P, %	37.28	23.25	21.35	13.96	.0013
Retained P, % of Ab.	86.55	64.41	61.23	49.23	.0031
Absorbed K, %	86.42	78.38	74.88	64.00	.0001
Retained K, %	13.68	17.99	13.56	16.33	.5200
Retained K, % of Ab.	16.01	22.31	18.61	23.75	.5472
Absorbed Mg, %	30.36	21.32	21.96	18.03	.1435
Retained Mg, %	16.35	14.76	17.98	15.46	.9059
Retained Mg, % of Ab.	40.12	50.12	59.84	60.38	.0061
Absorbed Cu, %	17.92	17.16	18.51	17.31	.8432
Absorbed Zn, %	20.19	15.54	18.71	13.81	.5390

[a]Calculated by difference.
[b]Probability of difference between rations.
[c]Basal corn-soybean ration.
[d]Feces substituted for 21.74% on DM basis.
[e]Feces substituted for 37.27% on DM basis.

EFFECT OF ANAEROBIC SWINE LAGOONS ON GROUND WATER QUALITY

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Anaerobic lagoons, because of their ease in construction and inexpensive maintenance, have become increasingly popular in the Coastal Region of Virginia. With the increase in confinement production of swine there is an increase in anaerobic lagoons. It has been established that discharge of effluent from anaerobic lagoons into ground water is undesirable. The effect of anaerobic lagoons on ground water quality has not been fully investigated. This study was initiated to monitor the effects of anaerobic lagoons on ground water quality. Preliminary results were reported in the 1973-74 Livestock Research Report.

Experimental Procedure

The lagoons under study were located in the Coastal Plains of Virginia at the Tidewater Research and Continuing Education Center (TRACEC), at the Virginia Swine Evaluation Station (VSES) and at a private farm in Suffolk. The lagoons were located on high water table soils ranging in texture from sandy loam to fine sandy loam. Wells were located at various depths and distances around the lagoons. The wells consisted of 2 in polyvinylchloride (PVC) pipe water jetted to depths of 10, 15 and 20 ft at distances of 10, 50 and 100 ft from the lagoons. Pea gravel was placed in the wells to permit undisturbed flow into the well and to prevent excessive uptake of sediment when sampling.

The wells were covered with a plastic cap containing a 2 in diameter PVC pipe that extended to a depth of 4 in from the well bottom. All joints were sealed with rubber cement to prevent outside contamination of the wells.

The wells were purged twenty-four hours before sampling. The samples were obtained with a "Sta-Rite" shallow well jet pump fitted with a 100 lb check valve and trap assembly. Containers for ground water samples were acid washed and sterilized. Samples for fecal coliform determination were transported to the laboratory at ambient temperatures and analyses were initiated within two hours after ground water samples were obtained from wells. Samples for chemical determinations were frozen and transported to Blacksburg for analyses. The frozen samples were allowed to reach ambient temperatures and filtered in preparation for chemical analyses. The ground water samples were analyzed for Cl^- and NH_4^+ by electrode procedures; NO_3^- by a phenoldisulfonic acid procedure; soluble orthophosphates by filtering through a .45 micron filter and then by an ascorbic acid method; fecal coliform by the millipore membrane procedure and; Cu^{++}, Zn^{++} and Mn^{++} by atomic absorption spectrophotometry.

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[3]Department of Agricultural Engineering.
[4]Department of Animal Science.

The wells were grouped into sets, each set consisting of wells at depths of 10, 15 and 20 feet. A tier of wells was made up of three sets of wells with a set located at distances of 10, 50 and 100 ft from the lagoons.

Results and Discussion

Virginia Swine Evaluation Center (VSES). Groundwater around the anaerobic lagoon located at VSES was monitored using two tiers of wells and two additional sets of wells. One tier was located at the southeast (SE) corner and the other at the northwest (NW). The additional well sets were located 10 ft from the lagoon at the southwest and northeast corners. The SE tier has been in operation since August 1973, whereas all other wells were in operation since September 1974. Data presented will be confined to analyses from September, 1974 through January, 1975 for the two tiers of wells.

Mean concentrations of NO_3^--N, NH_4^+-N, Cl^- and fecal coliform are shown in table 1. Neither the mean nor individual well values exceeded the United States Public Health Service (USPHS) drinking water standards for NO_3^--N, Cl^-, Cu^{++} or Zn^{++}. The USPHS standards are 10 ppm NO_3^--N, 250 ppm Cl^-, 1 ppm Cu^{++}, and 5 ppm Zn^{++}.

Mean NO_3^--N concentrations were less than 1 ppm; mean Cu^{++} and Zn^{++} concentrations were less than 0.1 ppm; and mean Cl^- concentrations were less than 150 ppm. NH_4^+-N concentrations were less than 1 ppm for 14 out of 18 wells. Two of the other four wells had mean concentrations above 10 ppm. Soluble orthophosphate values were less than 0.06 ppm in all but one of the wells. Soluble orthophosphates ranged from 4 to 7 ppm.

Fecal coliform were not observed in any of the wells after the first sampling date, except in the well having the high concentration of orthophosphate. The fecal coliform count in this well averaged 2000/ml and ranged from 9970/100 ml in September, 1974 to 4/100 ml in January, 1975.

Tidewater Research and Continuing Education Center (TRACEC). Three groups of wells were located around the anaerobic lagoon at TRACEC. Each group was made up of a set of wells at distances of 10 and 50 ft distances from the lagoon. The groups were located in the east (E) corner, west (W) corners, and in between these two, designated as center (C).

Mean NH_4^+-N were less than 1 ppm for all wells except the center 10 ft deep, 10 ft distant well. The mean NH_4^+-N concentration for this well was less than 5 ppm. With the exception of the 10 ft deep, 10 ft distant well in the west group, mean nitrates-N concentrations were less than 5 ppm. Mean NO_3^--N concentration for this well was less than 7 ppm. Mean concentrations of Cu^{++} and Zn^{++} were less than 0.1 ppm and mean concentrations of soluble orthophosphates were less than 0.06 ppm.

The high fecal coliforms means were due to the high counts observed during the first two months of sampling. No fecal coliforms were observed after the October sampling.

Private Farm. Two tiers were used to monitor ground water quality around the lagoon at the private farm. One tier was located in a slightly depressed area (F) and the other in a higher location (R).

NH_4^+-N and Cl^- values were considerably higher in the F tier. The mean NH_4^+-N values were as much as 100 times higher than wells similarly located in the R tier. Mean Cl^- were 10 to 20 times higher. Wells in the R tier showed a trend toward greater mean nitrate concentrations than that of wells in the F tier. Two wells in the F tier showed mean NO_3^--N values greater than 2 ppm, whereas, 8 out of 9 wells in the R tier were greater than 2 ppm. However, 8 of 9 wells in the F tier had greater than 5 ppm NH_4^+-N. None of the wells in the R tier had greater than 5 ppm NH_4^+-N.

Soluble orthophosphates did not exceed 0.06 ppm in any of the wells (values not presented). Cu^{++} and Zn^{++} were less than 0.1 ppm in all the wells (values not presented). The USPHS standards were not exceeded except for the mean Cl^- concentration in one well located in the F tier.

Mean fecal coliform in the R tier wells ranged from 0/100 ml to 496/100 ml. The high mean values is again attributed to contamination during well construction as fecal coliform numbers did not exceed 10/100 ml for any well after the first sampling in September, 1974. There were no fecal coliform bacteria in the wells located in the F tier.

Summary

Groundwater was monitored around three anaerobic swine lagoons located in the Coastal Plain Region of Virginia. NO_3^--N, NH_4^+-N, Cl^-, soluble orthophosphates, Cu, Zn and fecal coliform were determined for ground water samples obtained monthly from September, 1974, through January, 1975. USPHS standards for drinking water were not exceeded for the constituents monitored except for one well with over 250 ppm Cl^-.

Future work will entail bimonthly sampling of groundwater. Also soil samples will be collected from each site to determine the loading capacity of the soil and the loading effect of seepage from the lagoons on these soils.

TABLE 1

MEAN CONCENTRATION OF NO_3^--N, NH_4^+-N, Cl^-, AND FECAL COLIFORM AT VARIOUS DEPTHS AND DISTANCES FROM THE ANAEROBIC SWINE LAGOON LOCATED AT THE VIRGINIA SWINE EVALUATION STATION (HOLLAND, VA), THE TIDEWATER RESEARCH AND CONTINUING EDUCATION CENTER (HOLLAND, VA) AND A PRIVATE FARM (SUFFOLK, VA).*

Distance from Lagoon	Location	Well depth, feet											
		NO_3-N, ppm			NH_4^+-N, ppm			Cl^-, ppm			Fecal coliform/100 ml		
		10	15	20	10	15	20	10	15	20	10	15	20
Virginia Swine Evaluation Station													
10	C	2.91	0.24	<0.20	2.42	0.13	0.24	57.4	21.6	21.4	0.0	579.0	771.7
50	C	0.42	<0.20	<0.20	0.60	0.32	0.38	75.2	27.6	5.3	0.0	527.0	25.0
10	E	3.46	3.95	1.35	0.15	0.13	0.13	27.0	50.9	32.1	70.0	516.0	59.2
50	E	2.09	0.23	0.23	0.41	0.41	0.19	16.5	42.2	5.4	0.0	1920.0	12,266
10	W	6.85	<0.20	0.54	0.25	0.26	0.29	44.0	18.9	21.8	43.4	2404.0	2440.0
50	W	<0.20	<0.20	0.30	0.38	0.39	0.13	23.1	27.2	3.7	3.8	0.5	0.0
Tidewater Research and Continuing Education Center													
10	NW	<0.20	<0.20	<0.20	1.02	0.14	17.09	97.1	116.2	36.5	0.0	0.0	0.4
50	NW	<0.20	<0.20	<0.20	0.30	0.13	0.13	58.5	61.5	69.9	0.0	0.0	0.0
100	NW	<0.20	<0.20	<0.20	0.13	0.29	<0.10	40.6	78.7	11.4	0.0	0.0	1000.0
10	SE	0.25	<0.20	<0.20	47.05	0.23	3.00	42.0	11.9	5.0	1670.3	0.0	1.5
50	SE	<0.20	0.62	<0.20	0.16	0.14	0.20	10.5	5.5	30.6	0.0	0.0	0.0
100	SE	0.22	<0.20	<0.20	0.20	0.29	0.18	8.9	9.2	7.9	0.0	0.0	0.2
Private Farm													
10	F	0.59	0.26	0.19	366.50	10.92	41.62	297.5	108.5	131.0	0.0	0.0	0.0
50	F	0.35	6.39	0.32	9.96	73.62	127.93	145.0	129.0	205.0	0.0	0.0	0.0
100	F	1.18	7.63	0.24	8.81	88.17	2.09	208.5	93.5	7.2	0.0	0.0	0.5
10	R	7.49	5.56	2.35	0.18	0.14	0.34	13.9	10.7	7.1	146.8	0.0	0.0
50	R	2.75	4.84	4.61	0.18	0.18	0.21	6.7	9.6	7.6	0.0	496.0	4.8
100	R	1.09	2.61	5.95	0.12	0.17	3.48	6.2	5.0	9.6	17.4	2.0	28.0

*Mean of monthly samples from September 1974 through January 1975.

EFFECT ON SOIL AND PLANT MINERAL LEVELS FOLLOWING THREE ANNUAL APPLICATIONS OF SWINE MANURES OF DIFFERENT COPPER CONTENTS.

E. T. Kornegay[1], J. D. Hedges[1], D. C. Martens[2] and C. Y. Kramer[3]

For a third year control and high copper manures were applied to the same plots to determine the utility of certain chemicals and minerals in the manure and to identify any adverse effects on corn growth and grain composition of long term application. Results of the first two years work, reported in the 1973-74 Livestock Research Report, showed that in general copper, zinc, potassium, calcium and magnesium accumulate in the surface layer of the soil until the soil is plowed after which there is some increase in the lower layers. On the other hand, phosphorus moves downward, although the surface 4 in. contained the highest level. The copper content of the corn plant (ear leaf) was increased for corn grown on the plots receiving high copper manure; however, there was no increase in the copper content of the grain.

Procedure

As in previous years, fresh manure collected from finishing pigs fed rations with and without a growth stimulating level of added copper (300 ppm) was incorporated into the soil at a level of 26 tons on a wet basis (24% dry matter) per acre when the corn was about 4 in tall. The experimental treatments were: 1) no manure; 2) control manure applied; 3) high copper manure applied. The average composition of the manure on a dry matter basis was: 3.4% nitrogen, 1.6% phosphorus, 1.3% potassium, 2.4% calcium, 1.0% magnesium, 2310 ppm iron, 439 ppm zinc, 59 ppm copper (control manure) and 1330 ppm copper (high copper manure). These composition values are similar to those for the previous two years.

Results

Copper, zinc and magnesium levels in the soil continued to increase after the third year of applying swine manure. The increase in zinc and magnesium was evident for both control and high copper manures. These levels, however, are all well within safe or recommended levels for good crop production. Phosphorus and calcium were higher in plots receiving both types of manure, but did not increase after the first year. Iron and potassium levels of the soil were not significantly different among treatments.

Corn yields were increased on plots which had control and high copper manure applied as compared to the plots which had no manure applied.

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The copper content of the plant (ear leaf) was increased about two ppm over the previous year when the high copper manure was applied; however, the level of 12 ppm is well within a safe level even if the corn plant was to be used for silage. The phosphorus content was increased and there was a trend for the zinc content to be increased when both types of manure were applied. The iron, calcium, magnesium and potassium content of the corn ear leaf was not affected by treatments.

The copper content of the corn grain was not different among treatments, but the values were about twice as high as for the second year. The phosphorus content was increased and there was a trend for the zinc content to be increased when both types of manure were applied. The iron, potassium, magnesium and calcium levels were not affected.

Summary

In the present study there was no increase in the copper concentration of the grain with only a small increase in the copper content of the corn plant (ear leaf) when high copper manure was applied at a rate of about 26 ton/acre (24% dry matter) annually. There was an accumulation of copper in the surface layer of the soil when high copper manure was applied, but the level after three annual applications was well within a safe range for good crop production. When both types of manure were applied there continued to be an increase in the zinc, magnesium and phosphorus level of the soil. The phosphorus and zinc content of the ear leaf and the grain were increased slightly when both types of manure were applied. All increases observed could be beneficial.

TABLE 1. THE EFFECT OF MANURE APPLICATION ON THE SOIL MINERAL LEVELS. THIRD YEAR.

Soil depth, in.	Treatments: No Manure	Control Manure	High Copper Manure
	Copper, ppm[a,b]		
0-4	12.0	11.8	58.5[c]
4-8	10.7	11.2	24.8[c]
8-12	11.2	10.5	21.3[d]
	Zinc, ppm[a,b]		
0-4	35.1[e]	51.0	46.2
4-8	33.5	35.7	35.3
8-12	30.3	33.3	35.8
	Iron, %[a]		
0-4	2.5	2.6	2.3
4-8	2.3	2.6	2.5
8-12	2.5	2.5	2.3
	Phosphorus, ppm[f,g]		
0-4	43	60	60
4-8	34[h]	60	60
8-12	23[e]	60	60
	Potassium, ppm[f]		
0-4	109	100	106
4-8	113	123	132
8-12	102	120	107
	Calcium, ppm[b,f]		
0-4	364[h]	593	632
4-8	350	390	396
8-12	356	436	396
	Magnesium, ppm[b,f]		
0-4	95[e]	197	188
4-8	86[e]	115	120
8-12	95	132	127

[a]Total content.
[b]Treatment effect significant ($P < .01$), depth effect significant ($P < .01$) and depth times treatment interaction significant ($P < .01$).
[c]Significantly ($P < .05$) larger than other means at this depth.
[d]Significantly ($P < .01$) larger than other means at this depth.
[e]Significantly ($P < .01$) lower than other means at this depth.
[f]Dilute HCl-H_2SO_4 extractable.
[g]Treatment effect significant ($P < .01$).
[h]Significantly ($P < .05$) lower than other means at this depth.

TABLE 2. THE EFFECT OF MANURE APPLICATION ON MINERAL LEVELS OF THE EAR LEAF AND GRAIN. THIRD YEAR.

Minerals	Treatments: No Manure	Control Manure	High Copper Manure
	Ear leaf		
Copper, ppm	8.1	9.4	12.3[a]
Zinc, ppm	30.2	44.2	44.0
Iron, ppm	108.5	107.2	120.7
Phosphorus, %	.23	.33	.31
Potassium, %	1.12	1.03	0.95
Calcium, %	.44	.42	.44
Magnesium, %	.20	.19	.18
	Grain		
Copper, ppm	2.79	2.46	3.17
Zinc, ppm	20.7	24.2	25.0
Iron, ppm	20.8	21.9	21.9
Phosphorus, %	.25[b]	.29	.28
Potassium, %	.35	.34	.40
Calcium, ppm	49.2	43.3	45.2
Magnesium, %	.11	.12	.11

[a]Significantly ($P < .05$) higher than the other two means.

[b]Significantly ($P < .01$) lower than the other two means.

EFFECTS OF SWINE LAGOON EFFLUENT DISPOSAL ON SOIL-PLANT-RUNOFF QUALITY[1]

E. R. Collins, Jr.[2], D. C. Martens[3], and E. T. Kornegay[4]

Most industrial and municipal waste treatment systems are designed to provide sufficient treatment to permit discharge of effluent into receiving waters. The volume and high concentration of wastes from swine confinement units would require treatment costs and management far beyond the capabilities of most farmers. The most reasonable alternative is to design and manage systems so that swine wastes can be collected and applied to land in a controlled manner. For a large number of producers, this goal is accomplished by collecting manure in pits beneath slatted-floor housing, and draining or flushing liquid manure into anaerobic lagoons for a degree of waste stablization and solids destruction. Until recently, many lagoons were allowed to discharge into State waters. Effluent quality from such systems is not satisfactory to permit discharge under present environmental regulations, and a large number of producers must turn to land application of lagoon effluent as a functional and economical method of waste disposal.

Swine rations include not only components from natural sources such as crops, but also trace elements, pharmaceuticals, and salts. Some of these materials are concentrated in manure and are further concentrated in lagoon fluids. Serious questions are now arising concerning long-term repeated applications of swine lagoon effluent on agricultural lands. There is possibility of accumulation of certain materials in soils following application of manure. Much information remains to be developed regarding plant toxicity, uptake and accumulation of nutrients and other elements from swine wastes. Plant covers for waste disposal areas must be identified for Virginia conditions which will promote good infiltration characteristics and nutrient removal. Leaching characteristics of nutrients through the soil profile and effects on soil structure as a result of repeated heavy applications of waste waters must be studied. Effluent application rates which will minimize runoff must be determined for a variety of field conditions. Secondary pollution effects of precipitation runoff from disposal areas must be established.

This study was initiated to provide some of the preceding information needed by Virginia swine producers and regulatory agencies in making reasonable and sound decisions in the future. Specific objectives are:

1. To compare two systems of biological treatment for swine wastes in Virginia.

2. To monitor wastes from two confinement swine production facilities and effluent from their companion waste treatment systems to determine the degree of biological treatment afforded and fate of mineral feed constituents.

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[2] Department of Agricultural Engineering

[3] Department of Agronomy

[4] Department of Animal Science

3. To measure effects of application of lagoon effluent from the above systems on runoff water quality and pollutant accumulation in soil-plant disposal areas.

Experimental Procedures

Similar enclosed slatted-floor production pens, each containing equivalent live weight units of feeder pigs, have been operated over two separate waste collection pits since November, 1974. Pits are flushed into separate sealed concrete treatment tanks. One tank is operated as an anaerobic lagoon and the other is mechanically aerated at a rate equivalent to twice its estimated daily BOD_5. Tipping bucket flush tanks were constructed to recycle waste water from each treatment tank through its companion waste collection pit five times daily.

A permanent waste irrigation system has been installed to distribute treatment tank effluent on soil-plant disposal plots. Plots are established in tall fescue and are arranged so that runoff from both irrigation and rainfall events can be sampled. Each plot is also equipped with porous cups at depths of 6, 24, and 48 inches for sampling soil water and its constituents.

Samples of waste influent and treatment tank effluent have been taken monthly since December, 1974. Fecal coliform, pH, COD, minerals, NO_3^-/NO_2^--N, NH_4^+-N, TKN, Cl^-, total and dissolved solids, total and dissolved volatile solids, and total and dissolved ash determinations have been made but data has not been analyzed. Base-line determinations of the above constituents in the disposal plots have also been made by sampling soil cores and plant foliage.

Summary

Facilities to monitor an animal-soil-plant filter system at various stages to determine fate of certain constituents of swine wastes have been developed during the past year. Samples have been collected since December, 1974, to determine characteristics of raw wastes from collection pits and effluent from treatment units. Base-line levels of constituents in disposal plots are being determined.

Irrigation of wastes from each treatment system will begin in late Spring, 1975. Sampling of all stages of each system will be continued to obtain sufficient data to support meaningful conclusions.

TABLE 1. MEAN VALUES OF CONSTITUENTS OF RAW WASTES AND LAGOON EFFLUENT (PPM).[1]

	Fecal Coliform	COD	pH	Ca	K	Zn	P	Mg	Mn	Cu	Cl	NH_4	NO_3-NO_2	TKN	Total N
Anaerobic Unit															
Waste Influent	3,255,090	5570	7.42	143	410	3.60	9.71	64.73	1.17	0.28	458	604	7.73	816	1428
Unit Effluent	284,410	2486	7.52	72	337	1.35	5.95	45.18	0.34	0.10	335	504	4.40	574	1083
Aerobic Unit															
Waste Influent	4,123,368	4714	7.95	225	459	7.05	13.97	82.30	2.60	0.58	480	492	89.02	748	1329
Unit Effluent	527,659	1664	7.87	114	337	4.47	6.95	46.68	1.29	0.34	327	304	74.56	448	826

[1]Data collected December 1974 - May 1975.

TABLE 2. MEAN VALUES OF SUSPENDED, DISSOLVED, AND TOTAL SOLIDS; SUSPENDED DISSOLVED, AND TOTAL VOLATILE SOLIDS: AND SUSPENDED, DISSOLVED, AND TOTAL ASH CONTENT OF RAW WASTES AND LAGOON EFFLUENT (MG/L).[1]

	Suspended Solids (mg/l)	Dissolved Solids (mg/l)	Total Solids (mg/l)	Suspended Volatile Solids (mg/l)	Dissolved Volatile Solids (mg/l)	Total Volatile Solids (mg/l)	Suspended Ash (mg/l)	Dissolved Ash (mg/l)	Total Ash (mg/l)
Anaerobic Unit									
Influent	3446	2352	5798	2905	1164	4069	542	1185	1727
Effluent	392	1929	2321	257	1027	1284	135	903	1038
Aerobic Unit									
Influent	3870	2025	5837	3220	727	3947	716	1299	2015
Effluent	1310	1504	2770	1024	677	1701	317	837	1154

[1]Data collected December 1974 - May 1975.

TABLE 3. TOTAL N CONTENT OF FESCUE SAMPLES FROM BLACKSBURG EFFLUENT STUDY (DRY MATTER BASIS)[1]

Plot	Percent
#1	1.825
#2	1.968
#3	2.411
#4	2.181
#5	1.984
#6	1.722

[1]Initial sampling on January 8, 1975.