KENTUCKY ANIMAL SCIENCE RESEARCH REPORT 1971

Progress Report 196

UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Agricultural Experiment Station

1971 ANIMAL AGRICULTURE DAYS

UNIVERSITY OF KENTUCKY :: COLLEGE OF AGRICULTURE

July 21, 1971 - Coldstream Farm, Lexington

July 23, 1971 - Western Kentucky Substation Farm, Princeton

PROGRAM

9:00 - 11:30 a.m. - Visit research areas on the farm. The following are some of the topics to be discussed:

Beef Cattle

Beef Cattle Breeding Research.
Nitrogen Supplements for Finishing Steers.
Identification Systems.
Cow Herd Management.
Types of Beef Cattle.
Growing-Grazing-and Finishing Program.

Dairy

Greater Profits for Kentucky Dairymen.
Individual Stalls for Calves.
Modern Milking Management.
Mastitis Control Programs.
Protein Levels for Dairy Cows.

Swine

Practical Swine Nutrition.
Slotted Floors for Hogs.
Managing the Gestating Sow.
Managing the Feeder Pig.

Horses

Formulating Horse Rations.
Management Practices with Horses.
Current Research in Horse Nutrition.
Horse Parasite Control.

Sheep

Advances in Sheep Production.
Three Lamb Crops in Two Years.
Early Weaning Lambs.
Protein Supplements.

12:00 Noon - Barbecue lunch.

(July 21, Lexington—provided by Rural Electric Cooperative)

(July 23, Princeton—provided by Southern States Cooperative and Evansville Producers)

1:00 p.m. - Address by Dr. W. P. Flatt, Director, Georgia Agricultural Experiment Station, Athens, Ga.

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GENETICS AND PHYSIOLOGY SECTION

HISTOLOGICAL CHANGES IN THE CIRCULATORY SYSTEM WITHIN THE PAMPINIFORM PLEXUS AND TESTIS OF HEAT-STRESSED RAMS

R. S. Sand and R. H. Dutt

Blood flow in ram testes has been shown by use of a 133-Xenon washout technique to double initially and then to decline to approximately one-half control values by the fifth and seventh days of heat stress. Blood flow changes were similar with both whole body heat stress and with local application of heat to the scrotum, which suggests that a mechanism responsible for regulating testis blood flow rate is located in or near the testes. The role of the pampiniform plexus in regulating blood flow was studied. Histological sections of the circulatory system were prepared from the pampiniform plexus, testis and a portion of the spermatic artery anterior to the pampiniform plexus from control rams and from rams after 7 days of heat stress (32°C, 62 to 72% relative humidity).

No significant changes were detected in the venous vessels at any location sampled. Exposing the rams to heat for 1 week significantly increased thickness of arterial walls (Table 1). The arterial wall was significantly ($P < .05$) thicker anterior to the pampiniform plexus (21%) and at the top of the pampiniform plexus (22%). The increase (62%) in arterial wall thickness in the middle of the pampiniform plexus was highly ($P < .01$) significant. The treatment had no significant effect on arterial wall thickness at the base of the pampiniform plexus nor at the testis locations.

Table 1.—Mean Arterial Wall Thickness (microns) by Location for Treated and Control Rams

Group	Location[a]					
	Anterior Spermatic Artery	Pampiniform Plexus			Testis	
		Top	Middle	Base	Middle	Distal
Control	178[b]	171	125	098	095	076
Treated	216[c]	209[c]	202[d]	121	109	089
Percent change due to treatment	+21	+22	+62	+23	+15	+17

a/ Difference among locations highly significant ($P < .01$).
b/ Mean of 8 observations (2 sections from each testis from 2 rams).
c/ Significantly ($P < .05$) thicker than controls.
d/ Significantly ($P < .01$) thicker than controls.

Diameter of the spermatic artery in the middle of the pampiniform plexus was significantly (P .05) decreased by 28%. The decrease in arterial diameter suggests that this location may be the site of blood flow regulation to the testis. It should be pointed out that the arterial diameter was decreased from 4 to 28% at locations in the pampiniform plexus and increased from 14 to 16% in the testis from the treated rams (Table 2). Thus, there is no evidence to suggest that changes in the blood vessels within the testis were responsible for the decreased blood flow.

In the treated rams the mean cross-section area of the artery in the middle of the pampiniform plexus was 0.14 mm^2 compared with 0.27 mm^2. Exposure to heat stress reduced the area of the lumen of the artery in this region to 52% of that for control rams.

Changes induced in arterial wall thickness and lumen diameter in the mid-region of the pampiniform plexus by heat stressing indicate that the pampiniform plexus acts as a biological thermostat to control blood flow to the testes. Furthermore, results of this study suggest that the reduced blood flow may be responsible for spermatogenic impairment in heat-stressed rams.

Table 2.—Mean Arterial Diameter (microns) by Location for Treated and Control Rams

Group	Location[a]					
	Anterior Spermatic Artery	Pampiniform Plexus			Testis	
		Top	Middle	Base	Middle	Distal
Control	434[b]	568	589	459	389	269
Treated	391	535	426[c]	440	453	307
Percent change due to treatment	-10	-6	-28	-4	+16	+14

a/ Differences among locations highly significant ($P < .01$).
b/ Mean of 8 observations (2 sections from each testis from 2 rams).
c/ Significantly ($P < .05$) smaller than controls.

SEMEN CHARACTERISTICS IN THE RAM FOLLOWING TEMPORARY OCCLUSION OF THE BLOOD SUPPLY TO THE TESTES

R. S. Sand and R. H. Dutt

The volume of blood flow through the testes of rams has been shown to be affected by local and whole body heat stress. It appears that spermatogenic disruption in rams which accompanies heat stress may be the result of decreased blood flow through the testis. The study in this report accordingly was carried out to determine the effects of altering the blood flow to the testes of rams on subsequent semen characteristics.

Complete cessation of blood flow through the testes of rams by occlusion for 30 minutes or 1 hour had no significant effect on semen volume. Percent motile sperm cells, concentration, and percent morphologically abnormal sperm cells were all significantly affected by the treatment. Concentration of sperm cells was significantly ($P < .05$) reduced in the treated rams (Table 1). Mean concentration of sperm cells for the 12 weeks of the study was 1.9 and 1.7 million/mm^3 for the 30-minute and 1-hour occlusion groups, respectively, compared with 4.0 million/mm^3 for control rams. The difference between occlusion for 30 minutes and for 1 hour was significant ($P < .05$). Differences among weeks were also significant ($P < .01$). The treatment by week interaction was significant ($P < .01$), which can be accounted for by the nearly uniform start and finish concentrations and the wide divergence of the treatment means during the middle of the 12-week experimental period.

Percent motile sperm cells was significantly ($P < .01$) reduced by interruption of blood flow to the testis for short intervals. Occlusion of blood to the testis for 30 minutes and 1 hour decreased motile cells by 32 and 48%, respectively (Table 2). The variance in percent motile cells among weeks was highly significant ($P < .01$) as a result of time changes. The difference in percent motile cells among rams within treatments was significant ($P < .01$).

Percent morphologically abnormal cells was significantly ($P < .05$) increased 139 and 140% by occluding blood flow for 30 minutes and 1 hour, respectively (Table 3). Variation among weeks was highly significant ($P < .01$), and the treatment by week interaction was significant ($P < .05$). The increase in percent morphologically abnormal sperm cells following treatment shows that temporary interruption of blood flow to the testes interfered with maturation of the sperm cells. The decrease in sperm cell numbers and in percent abnormal cells from treated rams throughout the experiment shows that the treatments affected all stages of sperm cell development.

The detrimental effect on spermatogenesis was more severe following blood flow occlusion for 1 hour than for the 30-minute period. The similar effects of heat stress and blood occlusion on semen

characteristics lead to the conclusion that impairment of spermatogenic activity following heat stress may be caused by the reduced blood flow to the heated testis.

Table 1.—Mean Sperm Cell Concentration in Ram Semen Following Temporary Occlusion of Blood Flow to the Testes

Week[a] After Treatment	Duration of Blood Flow Occlusion		
	30 minute[b]	1 hour[b]	Control[c]
1	2.58[d]	4.06	3.94
2	1.40	2.78	4.09
3	0.70	1.17	4.10
4	1.31	0.80	3.65
5	1.16	0.84	4.02
6	1.24	0.52	3.41
7	1.30	1.15	4.33
8	1.58	1.12	4.53
9	1.64	1.10	3.81
10	3.68	1.38	4.36
11	3.20	2.49	4.10
12	3.26	3.03	3.82
Mean	1.92[e]	1.72[e]	4.01

a/ Differences among weeks are highly significant ($P < .01$).
b/ Mean of 2 observations from 2 rams.
c/ Mean of 2 observations from 4 rams.
d/ Sperm cell concentration in millions/mm^3.
e/ Significantly ($P < .05$) lower than controls.

Table 2.—Percent Motile Spermatozoa in Semen from Rams Following Occlusion of the Spermatic Artery

Week[a] After Treatment	Duration of Blood Flow Occlusion		
	30 minute[b]	1 hour[b]	Control[c]
1	60	38	57
2	35	27	69
3	18	5	61
4	20	18	60
5	47	17	60
6	32	17	55
7	32	32	64
8	47	30	65
9	40	25	55
10	60	30	60
11	65	55	65
12	63	53	57
Mean	43[d]	33[d, e]	63

a/ Difference among weeks are highly significant ($P < .01$).
b/ Mean of 2 observations per week from 2 rams.
c/ Mean of 2 observations per week from 4 rams.
d/ Highly significant ($P < .01$) lower than controls.
e/ Significantly ($P < .05$) lower than 30-minute rams.

Table 3.—Percent Morphologically Abnormal Spermatozoa in Semen from Rams Following Temporary Occlusion of Blood Flow to the Testis

Week[a] After Treatment	Duration of Blood Flow Occlusion		
	30 minute[b]	1 hour[b]	Controls[c]
1	37.6	31.1	17.3
2	46.0	44.9	8.7
3	18.2	24.6	7.5
4	27.4	26.0	8.9
5	26.4	20.6	10.9
6	20.4	33.1	12.4
7	28.5	25.1	7.7
8	28.1	21.1	9.1
9	30.2	25.1	15.2
10	17.2	21.5	9.5
11	11.2	17.1	9.8
12	16.1	18.5	11.1
Mean	25.6[d]	25.7[d]	10.7

a/ Difference among weeks was highly significant ($P < .01$).
b/ Mean of 2 observations from 2 rams.
c/ Mean of 2 observations from 4 rams.
d/ Significantly ($P < .05$) greater than controls.

HISTOLOGY OF THE REPRODUCTIVE TRACT OF SOUTHDOWN RAMS FED THE CHLOROHYDRIN (3-CHLORO-1, 2-PROPANEDIOL)

Jack L. Kreider and R. H. Dutt

The chlorohydrin (3-chloro-1, 2-propanediol) produces reversible infertility in rams when fed daily. However, until now the action of this compound on the ram reproductive tract was not known. The present study was conducted to determine the effects of this compound on the reproductive tract of the ram and to obtain information concerning the site of action on sperm cells.

Two mature Southdown rams of proven fertility were fed the chlorohydrin (3-chloro-1, 2-propanediol) in gelatin capsules at the rate of 62.5 mg/kg of body weight for 10 days. On the twelfth day after beginning the 10-day treatment period, both rams were slaughtered and their reproductive tracts were removed by dissection for laboratory study. Tissue samples of the accessory glands, testes and epididymides of each ram were fixed in a solution of 90% ethyl alcohol, 5% glacial acetic acid and 5% formalin. After fixation, samples were embedded in paraffin and sectioned with a microtome at a thickness of 6 microns. The sections were mounted on slides and stained with hemotoxylin and eosin for detailed microscopic study.

Gross examination of the reproductive tracts of both rams showed necrosis of the caput epididymis as evidenced by a greenish discoloration of the area. The corpus and cauda epididymis, as well as the accessory glands, appeared to be grossly normal.

Examination of the histological sections of the caput epididymis of treated rams showed severe disorganization of the tubular epithelium. There was also evidence of acute disruption of the stereocilia which border the epididymal epithelium. No apparent differences were observed between histological sections of the accessory glands of chlorohydrin-treated rams and a control. It is significant to note however, that the chlorohydrin treatment had a definite effect on the histology of the testes. Seminiferous tubules showed disorganization of the germinal elements and the lumen was completely occluded.

The dosage of chlorohydrin used in this study was two and one-half times larger than that used in a previous study in which, from semen studies, there was no evidence of disruption of spermatogenic activity. In the earlier study motility of sperm cells in treated rams decreased and fertility was blocked. When results of the two studies are considered, it is concluded that at low levels the chlorohydrin blocks fertility by acting at the epididymal level, whereas at higher levels it has a detrimental effect on the seminiferous tubules and spermatogenic activity.

ONE-DAY VS 14-DAY FLUSHING EFFECTS ON REPRODUCTION IN GILTS

C. P. Moore, R. H. Dutt, V. W. Hays and G. L. Cromwell

Increasing the energy level or "flushing" gilts before breeding is a common recommendation and generally accepted practice for increasing litter size. The present study was conducted to determine the effect of increasing the energy level only during the period of greatest follicular growth, i.e., during the first day of heat, on ovulation rate and litter size. Results will be compared with those following the usual 14-day flushing period and in unflushed control gilts.

In March, 36 gilts weighing approximately 245 lb each were randomly assigned at estrus to one of the following flushing treatments: (1) control -- 5.0 lb of feed daily; (2) 1-day flushing -- 5.0 lb of feed daily, except for a 24-hr period of ad libitum feed intake during estrus; and (3) 14-day flush -- 5.0 lb of feed daily, except for a 2-week period ad libitum feed intake starting on day 7 of the cycle. In June, 30 additional gilts were randomly allotted to the same treatments. All gilts were bred at the subsequent estrus and slaughtered on the 28th day of gestation.

Flushing for 1 day (14.8) or 14 days (15.4) significantly increased the average ovulation rate over controls (13.7). However, there was no significant difference between the two flushing treatments (Table 1). There was no significant difference in the average ovulation rate between the early spring bred gilts (14.9) and the summer bred gilts (14.4); however, there were significantly ($P<.01$) more live embryos per litter in the early spring bred gilts (13.4 vs 11.0).

Table 1.—Average Ovulation Rate in Gilts after 1- or 14-Day Flush

	Treatment			
Season	Control	1-day flush	14-day flush	Average
Spring	13.7	14.6	15.0	14.4
Summer	13.8	15.1	15.8	14.9
Average	13.7	14.8**	15.4**	14.6

**Significantly ($P<.01$) higher than controls.

Average live embryos per litter at 28 days gestation for control, 1-day flushing and 14-day flushing were 11.2, 11.9 and 13.0, respectively (Table 2). Flushing increased live embryos (1 day, 6.3%; 14 days, 16.1%) per litter over controls. The increase resulting from the 14-day treatment was significant ($P<.05$). There was no significant difference in litter size between the two flushing treatments. Average weight of embryos was not significantly affected by treatment (control, 1.40 vs treated, 1.33 g) or season (early spring, 1.31 vs summer, 1.40 g). There was no significant interaction between flushing and season in the traits studied.

Table 2.—Live Embryos per litter at 28 Days Gestation

Season	Treatment			Average
	Control	1-day flush	14-day flush	
Spring	12.0	12.8	14.4	13.1**
Summer	10.4	11.0	11.6	11.0
Average	11.2	11.9	13.0*	12.0

*Significantly ($P < .05$) larger than controls.
**Significantly ($P < .01$) larger than summer.

ESTRUS SYNCHRONIZATION OF GILTS FED AIMAX

D. L. Hammell, G. L. Cromwell, V. W. Hays and R. H. Dutt

An experiment involving 54 gilts was conducted to evaluate the efficiency of methallibure (AIMAX) for synchronizing estrus in gilts.

Crossbred gilts averaging 249 days of age at breeding were fed AIMAX at a level of 125 mg per day for 20 days (Table 1). Following withdrawal of AIMAX from the diet, all gilts exhibited estrus within 10 days, with an average of 6.46 days. Forty-eight (89%) gilts were synchronized within a 5-day period, from 4 to 8 days following AIMAX withdrawal. Most of the gilts were given two natural services at 24-hour intervals, beginning at the onset of estrus. Of the 54 gilts bred, 31 (57.4%) farrowed an average of 8.4 total pigs and 7.5 live pigs per litter. Gestation length varied from 111 to 117 days, with an average of 113.8 days.

Table 1.—Estrus Synchronization of Gilts with AIMAX[a]

Number of gilts	54
Following AIMAX withdrawal, Number showing estrus on:	
day 1	1
day 2	0
day 3	0
day 4	3
day 5	4
day 6	25
day 7	9
day 8	7
day 9	3
day 10	2
Number of gilts showing estrus	54
Number of gilts bred	54
Av days to estrus	6.46
Number of pigs farrowed	31
Farrowing rate	57.4
Gestation length - days	
range	111-117
average	113.8
Av number of pigs/litter	
born	8.4
born live	7.5

[a] Fed at a level of 125 mg/gilt/day for 20 days.

EFFECTS OF CHLORMADINONE ACETATE (ESTROSTAT) ON BREEDING EFFICIENCY OF BEEF HEIFERS

N. W. Bradley, J. A. Boling and D. R. Lovell

The preweaning and postweaning growth data and observations of estrus during the growing phase of this study were presented in the 1970 Kentucky Animal Sciences Research Report (Ky. Agr. Exp. Sta. Prog. Rpt. 188, p. 33).

At the termination of the 196-day postweaning growth phase of this study, the 45 heifers were turned to pasture as a group. While grazing they were offered ground ear corn free choice from a self-feeder. Four fertile bulls were turned with the heifers 23 days after the heifers were turned to pasture.

The bulls remained with the heifers for 89 days. During this time the heifers were observed for estrus, and dates of breeding were recorded. The heifers were slaughtered 21 days after the bulls were removed from the pasture. Carcass measurements were made at slaughter, and the ovaries and uterus examined. Crown-rump measurements were recorded on the isolated embryo from pregnant heifers.

The reproductive performance data are presented in Table 1. All heifers in group 3 (Estrostat at 0, 98 days in growing phase) were pregnant at slaughter. Six heifers in group 2 (Estrostat at 0, 70 and 140 days in growing phase) were not pregnant at slaughter. The heifers in this group returned to estrus later during the breeding phase of the study than those in group 3, which possibly resulted in the lower conception rate. Examination of the reproductive tracts at slaughter revealed no gross abnormalities in the one open heifer in the control group and the six open heifers in group 2.

Table 1.—Effects of Estrostat on Reproductive Performance of Heifers

	Treatment[a]		
	Group 1	Group 2	Group 3
Number of heifers	14	16	15
Avg age of first estrus, days	403	495	447
Number pregnant	13	10	15
Avg estrus cycles during breeding phase before conception[b]	1.5	2.0	1.8
Avg days to first estrus after last Estrostat injection	---	115	109
Avg estrus interval, days	---	19	21
Mean crown-rump length of fetus, mm	148.7	46.1	125.5

a/ Group 1 = Control heifers
Group 2 = 250 mg Estrostat injected at 0, 70, 140 days of growing phase.
Group 3 = 250 mg Estrostat injected at 0, 98 days of growing phase.

b/ One heifer was not observed in estrus but was pregnant at slaughter. Average includes only pregnant heifers.

Carcass data of the heifers are presented in Table 2. Carcass grade, dressing percentage or marbling score were not significantly ($P < .05$) affected by injection with Estrostat.

Table 2.—Carcass Data of Heifers at the Termination of Breeding Phase

	Group 1	Group 2	Group 3
	Control	Estrostat at 0, 70, 140 days	Estrostat at 0, 98 days
Number of heifers	14	16	15
Dressing %	63.4	63.8	63.2
Marbling score[a]	6.6	5.8	5.8
Carcass grade[b]	13.3	14.0	14.2

[a] Slightly abundant = 5, moderate = 6, modest = 7.
[b] Low choice = 12, avg. choice = 13, high choice = 14.

EFFECTS OF PMS DOSAGES ON BOVINE OVA PRODUCTION, RECOVERY AND FERTILIZATION

J. W. McGaugh and Durward Olds

Superovulation has been tried by many workers, and varying successes have been reported. Although many types of hormone preparations and dose rates have been used it is difficult to decide, on basis of the literature, which dose rate will produce the desired results. The present study was designed to determine the response and variability of cows to different doses of PMS (pregnant mare's serum

Four groups of 10 cows were given one, two, three, or four thousand international units (IU) of PMS on day 16 of the estrous cycle (heat = day 0). On day 19, 10 to 15 mg of estradiol benzoate or diethylstilbesterol were given. At the ensuing estrus, the cows were bred and injected with 2000 IU of HCG. All cows were slaughtered for ovum recovery 3 to 7 days after breeding.

In total, the 40 cows produced 410 ovulation points (10.3 per cow) and 211 ova were recovered (51.5%), of which 82 were fertilized (38.9%). On the average, each 1000 IU of PMS resulted in 5.82 ovulation points, 2.67 ova recovered, and 1.14 fertilized ova recovered. The number of ova ovulated, ova recovered and fertilized ova recovered from the oviducts and uterine horns and the number of cows producing them within each group is listed in Table 1. While the effects of dosage were linear, there was considerable variation among cows (not associated with age or weight of the cows), and it seemed that the fertilization rate was higher for 3000 IU (63.3%) than for the other dosages. Ovum recovery was more efficient (64.2%) when all ova were in the oviducts as compared with when they were in the uterus (34.2%).

Each additional 1000 IU of PMS increased the ovarian length by 9.67 mm, width by 8.04 mm, thickness by 4.42 mm, and weight by 17.87 g. Each ovarian variable was increased significantly as the interval from PMS to heat increased. The ovarian length seemed to be the most reliable predictor of ovulation point numbers and each centimeter resulted in 2.4 ovulation points.

Unless our evaluation of cleavage stages was occasionally in error, the cleavage rate in this study was about 33 hours per cleavage which is somewhat slower than might be expected in untreated cows as reported in the literature. From this study, a dosage of 3000 IU of PMS injected on day 16, 10 mg of estrogen injected on day 19, and 2000 IU of HCG injected at estrus appeared to produce the largest percentage of fertilized ova.

Table 1. Number of Ova Recovered and Fertilized Ova Recovered from the Oviducts and Horns and the Number of Cows Producing Them Within Each Group after Receiving Various Doses of PMS

	IU PMS				
	1000	2000	3000	4000	Overall
Ovulation points	22	65	128	195	410
Number of cows ovulating	8	9	10	10	37
Number of ova recovered	13	39	66	93	211
Number of Ova From:					
Oviducts	9	21	47	46	123
Uterine horns	4	18	19	47	88
Number of cows from which ova were recovered	6	7	9	10	32
Number of fertilized ova - total	6	3	42	31	82
From:					
Oviducts	5	1	34	16	56
Uterine horns	1	2	8	15	26
Number of cows from which the ova were recovered	3	2	8	7	20

RELATIONSHIP BETWEEN FERTILIZED OVA AND BACKFAT, SERUM LIPID LEVELS AND ENDOMETRIAL FAT IN BEEF COWS

B. V. Able, R. H. Dutt, F. A. Thrift and N. W. Bradley

The following study was initiated to determine if the amount of backfat in beef cows influences serum lipid level and endometrial fat content, and to determine if these traits are related to fertility. Forty-eight subfertile cows and 8 heifers were used in the study. The experimental cows were checked twice daily for a 60-day period with an aproned bull to detect estrus and to establish whether they were cycling normally. At the onset of the second estrus period, each cow was bred naturally and slaughtered 3 days later. The reproductive tracts were removed and ova were recovered by flushing the oviducts and uterine horns. Backfat measurements were made with a Bronson Model 12 Sonoray at a point 5 cm in front of the hip bones in the center of the back. Serum lipid levels were determined by a turbidity method on blood samples. Fat content of the endometrium was determined by an ether extract method.

Backfat measurements of cows ranged from 0.25 to 3.30 cm with a mean of 1.71 cm (Table 1). For heifers mean backfat measurement, 0.48 cm was significantly less ($P<.01$) than that of cows and ranged from 0.25 to 0.76 cm. The cows that had fertilized ova had less backfat than the cows with unfertilized ova (1.30 vs 1.83 cm), but the difference was not significant.

The cows had a significantly ($P<.01$) higher concentration of lipids (396.2 mg/100 ml) than the heifers (328.7 mg/100 ml). The serum lipid levels of cows with fertilized ova were higher than that of cows with unfertilized ova (384.5 vs 357.1 mg/100 ml), but the difference was not significant.

Endometrial fat content of the cows ranged from 0.33 to 3.1% and for heifers, from 1.3 to 2.6%. The mean endometrial fat content of heifers was significantly ($P<.05$) higher than that of cows (1.63 vs 1.12%). There was no significant difference in endometrial fat content between fertilized cows (1.3%) and unfertilized cows (1.1%).

Table 1.—Backfat Thickness, Serum Lipid Level and Endometrial Fat Content of Cows and Heifers

Treatment Group	Backfat Thickness, cm	Serum Lipid, Mg/100 ml	Endometrial Fat, %
Cows	1.71[a]	396.2[b]	1.12[c]
Heifers	0.48	328.7	1.63
Females having:			
Fertilized ova	1.30	357.1	1.30
Unfertilized ova	1.83	384.5	1.10

[a] Significantly ($P < .05$) less than heifers.
[b] Significantly ($P < .01$) higher than heifers.
[c] Significantly ($P < .05$) less than heifers.

Correlations between each of the parameters of backfat, serum lipid levels and endometrial fat content were determined. In cows there was a positive correlation between backfat and uterine fat (0.23), and also between serum lipid content and backfat (0.18). However, neither correlation was significant. The correlation between backfat and uterine fat (0.06) in heifers was not significant, but a significant ($P < .05$) positive correlation (0.69) was found between the serum lipid content and backfat.

In the cows that had fertilized ova a significant ($P < .05$) positive correlation (0.81) was found between the serum lipid level and backfat, but endometrial fat content was not significantly correlated (0.16) with backfat. In these females serum lipid level was negatively correlated (-0.22) with endometrial fat, but it was not significant. A negative correlation (-0.48) between uterine fat and backfat was significant in the cows with unfertilized ova. The correlation (0.43) between serum lipid levels and backfat approached significance. There was a non-significant negative correlation (-0.35) between serum lipid levels and uterine fat content in unfertilized cows.

PLASMA AMINO ACID PATTERNS AND NITROGEN CONSTITUENTS IN YEARLING BULLS AND HEIFERS WITH DIFFERENT RATES OF GROWTH

J. A. Boling, F. A. Thrift and D. L. Cross

Several blood constituents have been measured in growing cattle and attempts made to relate their levels to growth rate or performance. This study was designed (1) to measure plasma urea, protein and free amino nitrogen in 63 Hereford bulls and 76 Hereford heifers at the end of a 160-day postweaning period and (2) to measure plasma free individual amino acids in the 12 high- and 12 low-gaining bulls and the 12 high- and 12 low-gaining heifers based on their rate of growth to 365 days of age. Jugular blood samples were collected in heparinized tubes 2-4 hr after the morning feeding at the end of the 160-day postweaning period. The bulls were fed a corn and cob base ration ad libitum which was calculated to contain 10.7% crude protein. The heifers grazed pasture for 30 days and were fed 0.45 kg soybean meal and 1.36 kg ground shelled corn daily plus corn silage free choice for the remainder of the 160-day period.

Plasma protein, free amino nitrogen and urea nitrogen averaged 8.41 g/100 ml, 56.38 µg/ml and 17.19 mg/100 ml, respectively, for the 63 bulls. These same plasma constituents for the 76 heifers were: protein, 7.52 g/100 ml; free amino nitrogen, 52.92 ug/ml and urea, 7.65 mg/100 ml.

The growth data of the high and low-gaining groups of bulls and heifers are presented in Table 1. Plasma protein, free amino nitrogen and urea nitrogen were not significantly different ($P > .05$) between the high- and the low-gaining groups of bulls or heifers. Aspartic acid (µm/100 ml) was lower ($P < .10$) in the high-gaining group of bulls, but the concentrations of the remaining individual amino acids were not significantly different. The concentrations of the individual amino acids were not significantly different between the high- and low-gaining groups of heifers. When calculated on a molar percentage basis, valine was higher ($P < .10$) in the high-gaining group of heifers.

Table 1.—Growth Data for High and Low-Gaining Yearling Bulls and Heifers[a]

Trait	Bulls		Heifers	
	High	Low	High	Low
205-day wt, kg	198.3	177.8	187.3	144.7
365-day wt, kg	391.8	329.0	278.3	216.1
Postwean ADG, kg	1.21	0.96	0.57	0.44

[a] Twelve animals per group.

In both the bulls and heifers, the concentrations of most of the individual amino acids were slightly negatively correlated to postweaning average daily gain. Proline (-0.51) and tyrosine (-0.54) were significantly ($P < .01$) negatively correlated to postweaning gain in the bulls and isoleucine (-0.46) and aspartic acid (-0.40) were significantly ($P < .05$) negatively correlated to postweaning average daily gain in the heifers.

PHENOTYPIC RESPONSE AND TIME TRENDS TO DATE OF BIRTH SELECTION IN SOUTHDOWN SHEEP

F. A. Thrift, R. H. Dutt and P. G. Woolfolk

Data collected over a 14-year period were utilized for estimating phenotypic response and time trends to date of birth selection in a flock of purebred Southdown sheep.

To determine the influence that selection for date of birth had on the overall performance of the flock, data were analyzed separately for lamb and ewe traits. The lamb traits studied were date of birth, birthweight, rate of gain from birth to 120 days, 120-day weight, and 120-day fleece length; the ewe traits studied were lambs born per ewe exposed, lambs reared per ewe exposed, percent ewes lambing, lambing date, lambs born per ewe lambing, lambs reared per ewe lambing, date of first estrus, ewe wool weight and ewe body weight. Least squares means were estimated and regressed on years to determine the average yearly phenotypic change for the lamb and ewe traits.

Although nonsignificant, regressions for the lamb traits suggest that date of birth (-0.739 ± 0.513) became earlier; whereas, rate of gain from birth to 120 days (-0.013 ± 0.008) and 120-day weight (-0.145 ± 0.096) declined, but birth weight (0.006 ± 0.011) and 120-day fleece length (0.010 ± 0.008) increased over the years. The average selection differential per year and phenotypic change per generation for date of birth were -16 and -2.1 days, respectively, for ram lambs surviving to 120 days. Significant regressions indicated that lambs born per ewe exposed (0.035 ± 0.008), lambs born per ewe lambing (0.016 ± 0.007), lambs reared per ewe exposed (0.039 ± 0.008), lambs reared per ewe lambing (0.029 ± 0.007) and percent ewes lambing (1.410 ± 0.333) increased and lambing date (-1.266 ± 0.466) became earlier over the years. Although nonsignificant, regressions for date of first estrus (-0.402 ± 0.756) and ewe body weight (-0.274 ± 0.283) were negative; whereas, the regression for ewe wool weight (0.017 ± 0.020) was positive.

EFFECTS OF POPULATION STRUCTURE ON RESPONSE TO SELECTION, USING *TRIBOLIUM CASTANEUM*

R. Goodwill

Theoretical studies have indicated that a system of within-between line selection may lead to greater long-term response than simple mass selection. The flour beetle, *Tribolium castaneum*, is being used to compare two systems of within-between line selection with mass selection.

In each system the number of breeding individuals is fixed at 18 males and 36 females (each male is mated to two females) and selection for heavier 21-day pupa weight is performed on a within half-sib family basis. The size of the half-sib family, when possible, is limited to 10 males and 10 females to

maintain equal selection intensities in each system. Treatment 1 (mass selection) consists of a single population. In treatment 2 the population is divided into 6 lines (3 males; 6 females each) and selection is performed within each line. Every 4th generation the best two lines are selected and crossed to produce 6 new lines. Treatment 3 is the same as treatment 2 except between line selection is performed every 8th generation instead of every 4th. A population that is randomly bred and randomly selected is being maintained as a control.

The average pupa weights (in micrograms) for each treatment before selection (Gen. 0) and after 8 generations of selection (Gen. 8) are shown in Table 1. The average response per generation in Table 1 was estimated by regressing the accumulated response (measured as a deviation from control) on generations of selection. The significant F values (Table 1) indicate that response has been linear over time.

Table 1.—Average Pupa Weight of Flour Beetle in Gen. 0 and Gen. 8, Average Response per Generation and F Test for Linear Response for the Three Systems of Selection

	Trt. 1	Trt. 2	Trt. 3
Av pupa wt. (mcg.)			
Gen. 0	2419	2471	2457
Gen. 8	2667	2600	2687
Av response/Gen.	19.5±5.2	7.5±2.3	21.5±4.3
F value	7.4*	15.3**	24.7**

*Denotes significance at .05 level.
**Denotes significance at .01 level.

The results from these early generations of selection indicate that treatment 2 is the least effective system for improving pupa weight. No significant differences were observed between treatments 1 and 3. The experiments are being continued to measure the effects on long-term response.

GENETIC CORRELATIONS BETWEEN SEMEN AND GROWTH TRAITS MEASURED ON YEARLING SOUTHDOWN RAMS

T. P. Goerke, F. A. Thrift and R. H. Dutt

As part of a study designed to estimate heritability of semen traits measured on yearling Southdown rams in July, genetic correlations were estimated between the semen traits and certain preweaning and postweaning growth traits of the rams.

Semen volume, sperm cell concentration, percent motile sperm cells and percent abnormal sperm cells were the semen traits evaluated. Preweaning rate of gain, 120-day weight and postweaning rate of gain were the growth traits evaluated. These data include the records of 171 yearling Southdown rams collected over the 12-year period, 1958-70.

Genetic correlations and standard errors for the various traits are presented in Table 1. The genetic correlations between sperm cell concentration and the growth traits are moderate to high in magnitude; however, in each case the standard errors are larger than the correlations. These results suggest that many of the genes responsible for an increase in growth rate also may be responsible for increased sperm cell concentration.

Semen volume does not appear to be related to any of the growth traits, since the genetic correlations were low.

Table 1.—Genetic Correlations Between Semen Traits and Growth Performance Traits

Traits	Correlation
Sperm cell concentration - postweaning rate of gain	1.70±2.90
Sperm cell concentration - 120-day weight	0.58±1.24
Sperm cell concentration - preweaning rate of gain	0.57±1.20
Semen volume - postweaning rate of gain	0.10±0.58
Semen volume - 120-day weight	0.00±0.42
Semen volume - preweaning rate of gain	0.06±0.40
Percent motile cells - postweaning rate of gain	0.77±1.27
Percent motile cells - 120-day weight	-.06±0.75
Percent motile cells - preweaning rate of gain	-.03±0.71
Percent abnormal cells - postweaning rate of gain	-1.03±0.65
Percent abnormal cells - 120-day weight	-.40±0.45
Percent abnormal cells - preweaning rate of gain	-.46±0.43

A positive genetic correlation exists between sperm cell motility and postweaning rate of gain. However, the correlation between sperm cell motility, 120-day weight and preweaning rate of gain are small and negative. These results suggest that those genes responsible for increasing postweaning rate of gain also may be responsible for increasing percent motile sperm cells.

The negative genetic correlation between the growth traits and percent abnormal sperm cells suggest that selecting rams with faster preweaning and postweaning rates of gain should result in a lower percent of abnormal sperm cells in their semen.

The favorable genetic relationship between the growth traits and the semen traits indicates that, in general, selection of rams with faster preweaning and postweaning rates of gain should result in an overall increase in semen quality.

THE MODE OF INHERITANCE OF "WHITE HEIFER DISEASE"

R. C. Bennett and Durward Olds

White heifer disease is a severe genetic defect of female bovine reproductive organs characterized by aplasia of portions of one or both uterine horns, persistent hymen, narrow vagina, and persistence of Mullerian bodies.

The only extensive study of the abnormality and its genetic basis in the United States was reported in 1926 by Fincher and Williams of Cornell University. They found that when a bull was bred to his daughters, 12 out of 23 of the female offspring were completely sterile with varying degrees of abnormality similar to white heifer disease. Gregory et al., of California, studied the Cornell data and concluded that the bull was homozygous for an autosomal recessive gene (ww). Roberts, in his book Veterinary Obstetrics and Genital Diseases, inadvertently misquoted Spriggs (a British researcher) when he said "This condition is considered by Spriggs to be caused by a single, recessive, sex-linked gene with linkage to the gene for white color." From the observed frequency in the Cornell study, a definite conclusion cannot be made as to whether the condition was sex-linked or autosomal because the expected ratio of normal to abnormal animals would be 1:1 in both instances.

From 1960 to 1964, two cases of similarly defective Holstein animals appeared in the University of Kentucky dairy herd and four more were encountered in other herds. Of the six preliminary animals mentioned, all were sired by one bull, Wis White Standard, which was used by KABA for 9 years and had bred 42,000 cows.

In 1965, a project was approved for the purchase of Wis daughters to study the white heifer disease syndrome and to determine whether the defective gene is autosomal or sex-linked. Results of the 5-year study of various matings are presented in Table 1.

Table 1.—The Occurrence of White Heifer Disease When "Wis" Daughters were Bred to "Wis" or to "Wis" Sons

Bulls Tested		Female Offspring	
		Normal	Abnormal
Wisconsin		37	12
Inbred Sons	(Alpha	11	2
	(Gamma	6	0
Outbred Sons	(Eastern	14	0
	(Belcher	10	0
	Total	78	14

Wis, when mated to his daughters, produced 12 abnormal and 37 normal daughters, a ratio of 1:3.08 which was significantly different from 1:1 which would be expected if the sire was homozygous (ww) or if the defective gene was sex-linked (Xw) and also from the 1:7 which would be expected if the sire was heterozygous (Ww). However, the possibility of homozygosity was virtually eliminated by the fact that two outbred sons produced 24 normal and no abnormal offspring when mated to Wis daughters. The possibility of sex linkage was strongly negated by one outbred son, at another university, siring one abnormal heifer. The possibility of heterozygosity was strengthened by the fact that two inbred sons, when mated to Wis daughters, produced 41 normal and 2 abnormal offspring, a ratio which would be expected. Since 5 of the abnormals had abnormalities of the right uterine horns, 3 had left and 4 had both, it is possible (and seems likely) that two genes (L1Rr), one for right and one for left uterine horns, are involved, as shown in Table 2.

Table 2.—Actual and Expected Frequencies of Left and Right Uterine Horn Abnormalities When "Wis" is Bred to His Daughters and Assuming "Wis" to be Heterozygous (L1Rr)

	Observed	Expected	Chi Square
Normal	37	37.5	.007
Right horn abnormal	5	5.3	.017
Left horn abnormal	3	5.3	1.000
Both horns abnormal	4	.8	12.750
		$P < 0.005$	13.774

The observed and expected frequencies are in close agreement as shown by the small chi square values except for more animals with both horns affected being observed than would be expected. This is very likely to occur under experimental conditions when such small numbers of animals are involved. By grouping all abnormal animals together, but still assuming Wis is LrRr, there is very close agreement between the observed and expected frequencies.

	Observed	Expected
Normal	38	37.5
Abnormal	12	11.5

The observed data in this experiment more closely fit the two-gene hypothesis (LrRr), and it seems likely that Wis possessed the two-gene heterozygous genotype.

ANIMAL FOODS SECTION

EFFECT OF DIETARY PROTEIN AND ENERGY LEVELS ON CARCASS AND PALATABILITY CHARACTERISTICS OF SWINE

James R. May, James D. Kemp, V. Trujillo, G. C. Cromwell, V. W. Hays, and W. G. Moody

Carcass characteristics and palatability data were collected on 72 crossbred barrows and gilts (8 per treatment group) that were fed rations with three energy levels as shown in Table 1.

Table 1.—Protein and Energy Levels in Rations

Group	Protein	Metab. Energy Kcal/lb	Addition to Ration for Energy Adjustment
1	12	1,700	10% fat
2	12	1,500	10% dextrose
3	12	1,300	10% sand
4	16	1,700	10% fat
5	16	1,500	10% dextrose
6	16	1,300	10% sand
7	20	1,700	10% fat
8	20	1,500	10% dextrose
9	20	1,300	10% sand

The ration was basically a corn-soybean meal mixture with energy levels adjusted by using fat, dextrose or sand. The pigs were slaughtered when they reached approximately 210 lb. After a 48 hr chill, the carcasses were measured and cut and a section of the loin from the 10th to the 14th rib was frozen and later thawed, cooked to an internal temperature of 170°F and evaluated by a seven-member palatability panel for tenderness, flavor, juiciness, and overall satisfaction. Two one-inch cores were obtained and sheared on a Warner-Bratzler shear device for tenderness.

Table 2 summarizes the results. The data have not yet been statistically analyzed so no conclusions may be drawn. Observation of the data indicates, however, that pigs in group 1, the low-protein - high-fat group, had the lowest average percent ham and loin and lean cuts and the lowest shear values indicating it was the most tender. Many of the averages were similar for the different treatments.

Table 2.—Summary of Carcass, Palatability and Shear Data

Group	Final Live Wt,	Carcass			Loin Eye Area	Quality[a] Score	Ham & Loin	Lean Cuts	Palatability Scores[b]			Overall Satis.	Shear[c] Values
		Wt	Length	Backfat					Flavor	Juiciness	Tenderness		
	lb.	lb.	in.	in.	sq in.		%	%					
1	208	149.1	30.3	1.43	4.38	2.75	39.3	55.1	7.1	7.2	7.5	7.2	13.7
2	216	153.6	30.9	1.30	4.62	2.75	39.8	55.3	7.1	7.1	7.1	7.0	18.2
3	214	150.7	30.2	1.23	4.90	2.50	41.3	57.7	7.2	6.7	7.4	7.0	15.1
4	216	156.6	30.6	1.25	5.44	2.50	41.0	56.6	7.1	7.0	7.4	7.1	15.5
5	216	156.3	30.0	1.48	5.86	3.00	41.5	57.8	7.0	6.8	7.1	6.9	16.6
6	212	149.4	30.7	1.10	4.88	3.00	41.3	58.0	7.0	6.6	6.7	6.8	16.8
7	216	152.7	30.7	1.28	4.77	2.37	41.3	57.7	7.1	6.7	7.2	7.0	17.3
8	213	150.8	30.7	1.32	4.82	2.75	40.3	56.5	6.9	6.7	7.0	7.0	16.2
9	207	144.7	30.4	1.17	4.77	2.37	40.5	56.6	7.0	6.6	7.1	6.9	18.1

[a] Based on Wisconsin standards
[b] Based on 9-point hedonic scale
[c] Lb force to shear one-inch core

PROPERTIES OF HAM AND LOIN MUSCLES AS AFFECTED BY PORK QUALITY, CUTABILITY AND ANATOMICAL LOCATION

W. R. Henning, W. G. Moody and J. D. Kemp

Histological, chemical and tenderness evaluations were made on four muscles of the ham and four anatomical locations within the loin on cuts taken from two quality groups and two cutability groups. Hams from six high-cutability (42% ham and loin) carcasses were selected to measure differences in histochemical and physical characteristics among major ham muscles, among locations within the loin, and between cutability types. The right hams were dissected fresh, and the left hams were dry-cured and aged for 4 months and then dissected. Muscles involved were the biceps femoris (V), semimembranosus (VI), semitendinosus (VII) and adductor (VIII). Samples were also taken from four anatomical locations of the longissimus. The loin from the left side of each carcass was sampled at the 5th thoracic (I), 10th thoracic (II), 1st lumbar (III) and 5th lumbar (IV) vertebrae. The samples were cut 5.1 cm thick with the anterior 2.54 cm used for chemical and histological determinations and the posterior portion used for shear values.

Table 1 shows the means of the chemical, physical and histological observations between the two cutability groups. Samples from the low-cutability group showed lower shear values and higher ether extract values, but there was no difference in moisture. The low-cutability group showed a slightly greater proportion of white fibers both in the loin and ham, but the high-cutability group tended to have larger red and white fibers. There was very little difference in the shrinkage of the ham muscles, but the low-cutability group showed a higher salt content after aging.

Table 1.—Chemical, Physical and Histological Observations of Muscles from Pork Carcasses of High and Low Cutability

	Low Cutability	High Cutability	S. E.[c]
Shear avg (kg)			
Loin samples[a]	38.58	44.11	4.18
Ham muscles[b]	40.77	46.69	4.16
Moisture (%)			
Loin samples[a]	71.02	70.57	2.71
Ham muscles[b]	72.29	72.50	1.62
Ether Extract (%)			
Loin samples[a]	6.12	3.53	0.77
Ham muscle[b]	5.33	3.82	.57
White to red fiber ratio			
Loin samples[a]	2.26	2.04	.29
Ham muscles[b]	1.13	1.09	.20
White fiber size (mm^2)			
Loin samples[a]	5.23	5.91	.66
Ham muscles[b]	6.60	6.76	.67
Red fiber size (mm^2)			
Loin samples[a]	2.03	2.51	.29
Ham muscles[b]	3.05	3.40	.42
% Shrink[b]	39.74	38.64	2.94
% NaCl[b]	8.57	6.90	0.59

[a] Mean values for 4 sampling locations within the longissimus.
[b] Mean values for biceps femoris, semimembranosus, semitendinosus and adductor muscles of the ham.
[c] Standard error.

Table 2 shows the mean values of the chemical and physical observations between quality groups. The high quality group had slightly lower shear values, the greatest differences being in location III and in the adductor. The ether extract values were consistently higher for the high quality muscles. The muscles from the high quality hams appeared to have a greater relative weight loss and a higher salt content.

Table 2.—Chemical and Physical Observations of Muscles from Pork Carcasses of High and Low Quality

	High Quality	Low Quality	S. E.
Shear avg (kg)			
Loin samples[a]	38.58	41.23	4.19
Ham muscles[b]	41.27	45.57	4.15
Moisture (%)			
Loin samples[a]	70.98	72.73	2.70
Ham muscles[b]	72.29	73.57	1.61
Ether Extract			
Loin samples[a]	6.12	2.96	0.79
Ham muscles[b]	5.33	2.47	.58
% Shrink[b]	3.98	3.60	2.88
% NaCl[b]	8.55	6.65	0.60

a/ Mean value for 4 sampling locations within the longissimus.
b/ Mean values for biceps femoris, semimembranosus, semitendinosus and adductor muscles of the ham.

Table 3 shows a comparison of the chemical and physical observations among individual muscles. No differences in tenderness could be observed among the loin samples, but the semitendinosus and adductor appeared to be the most tender in the ham. There were no differences in moisture in any of the samples. However there was considerable variation in ether extract values among locations within the loin. The semitendinosus contained the greatest amount of ether extractable lipids of any of the four ham muscles studied.

Table 3.—Chemical and Physical Observations of Samples Taken at Four Locations and from Four Muscles

Muscle	Shear Avg (kg)	S.E.	Moisture (%)	S.E.	E.E. (%)[a/]	S.E.
Longissimus						
I (5th T.)	41.59	3.39	68.29	4.11	4.53	.48
II (10th T.)	40.66	1.77	72.34	.35	4.01	.36
III (1st L)	41.31	2.12	73.23	.43	3.06	.29
IV (5th L)	41.67	1.92	71.89	.52	5.02	.51
Ham						
V (BF)	48.11	2.14	73.45	.30	3.57	.26
VI (SM)	48.42	2.29	73.98	.24	2.62	.27
VII (ST)	39.23	2.25	69.90	2.34	6.67	.44
VIII (Add)	42.28	2.73	73.81	.29	2.62	.21

a/ Ether extract.

Table 4 shows the mean histological measurements on samples from the loin and ham. No consistent differences were found for fiber type among locations within the longissimus, although samples from the anterior end tended to have a higher proportion of red fibers. Both red and white fibers tended to increase in size from the anterior to the posterior end of the wholesale loin. The adductor muscle showed the greatest proportion of red fibers when stained with reduced diphospho-nucleotide tetrazolium reductase (DPNH-TR) and the semimembranosus the greatest proportion of white fibers. The biceps femoris contained the largest red and white fibers but the other muscles showed no consistent pattern.

Table 4.—Histological Observations of Samples from Four Sampling Locations and Four Muscles

Longissimus	White:Red	S.E.	White Area (MM^2)	S.E.	Red Area	S.E.
I (5th T)	1.73	0.24	4.95	0.65	2.15	0.30
II (10th T)	2.40	.21	5.32	.39	2.25	.18
III (1st L)	2.20	.14	6.05	.28	2.15	.16
IV (5th L)	2.25	.23	5.95	.55	2.56	.16
Ham						
V (BF)	1.06	0.14	7.27	0.50	3.51	0.39
VI (SM)	1.23	.16	6.87	.53	3.22	.38
VII (ST)	1.16	.11	6.38	.57	3.31	.27
VIII (Add)	.99	.15	6.93	.44	2.84	.16

In summary, the low-cutability and high quality carcasses tended to be more tender and were higher in fat content. No differences were shown in weight loss of the whole ham, but the muscles of the high quality carcasses tended to have a higher shrink. The semitendinosus and adductor were the most tender of the ham. The semitendinosus contained the most extractable lipids whereas the biceps femoris had the largest fiber areas. No consistent histological differences were observed within the loin.

RELATIONSHIP OF FRESH HAM TRAITS TO CURED HAM QUALITY

James D. Kemp, J. D. Fox, W. G. Moody and J. D. Crouse

This study was designed to study further the relationships between pH, myoglobin content and expressible juice with various cured ham traits, to ascertain differences in cured characteristics owing to fresh ham quality and to determine protein losses during holding and curing.

Twenty-four hams ranging in weight from 14.1 to 21.3 lb, including 12 with low quality (Wisc. score of 1) and 12 with high quality (Wisc. score of 3 or 4) were selected from the 1970 Louisville Barrow Show. No attempt was made to identify hams by genetic or nutritional backgrounds. The hogs were slaughtered and the carcasses chilled in a conventional manner, and the carcasses were cut approximately 44 hours later. Selected hams were placed in individual plastic bags and trucked the next morning 80 miles to the University of Kentucky Meat Laboratory. On arrival, the exudate was collected from those hams having sufficient quantity for analysis.

pH values were determined on the gluteus medius muscle, after which a sample was obtained to determine myoglobin and expressible juice.

All hams were grouped in respect to high and low quality and dry-cured in plastic vats for 34 days using 8 lb of salt-sugar cure per 100 lb of fresh hams. The curing mixture contained 73.6% salt, 24.5% white sugar, 1.2% potassium nitrate and 0.6% sodium nitrate and was applied in 3 equal applications at 5-day intervals. The curing exudate was collected at the time of the second and third cure applications and after removal from cure.

After curing, the hams were brushed of excess salt and allowed to equilibrate for 27 days at 36 to 38°F. They were then rinsed with warm water, placed in stockinette, hung in a smokehouse to dry and smoked at approximately 100°F for approximately 24 hours. The hams then were aged at 75°F and 65% relative humidity for 5 months. Weight loss was determined by weighing the hams before cure, after cure, after smoking and after aging 3 and 5 months. Hams were cut and rated for color (dark red, red or light red), odor (typically aged, moderately aged or slightly aged), and general appearance (excellent, good or fair).

Myoglobin was determined as total pigment on a sample of the gluteus medius. A Beckman flat surface electrode was used to measure the pH of a freshly cut surface of the muscle. Expressible juice

was determined by pressing a 2 g sample of the gluteus medius on a Whatman No. 2 filter paper for 5 minutes with a 50 lb weight. The total area wetted was measured with a compensating polar planimeter.

Center slices, one-half inch in thickness, were broiled and samples were served in duplicate to a seven-member palatability panel who evaluated them for tenderness, flavor, saltiness and over-all satisfaction. One slice from each ham, one inch in thickness, was broiled and allowed to cool at room temperature. A one-inch core was removed from each semimembranosus (SM), semitendinosus (ST) and biceps femoris (BF) muscle and was sheared with a conventional Warner-Bratzler (W-B) shear device and a similar device mounted on an Instron (Ins.) instrument.

There were significant differences in the two groups of hams as denoted by myoglobin content, pH values and press juice (Table 1). Myoglobin content of the gluteus medius muscle was 1.59 mg per g of muscle in the high quality group but only 0.68 mg per g in the low quality group. Average pH values were 5.94 vs 5.43 ($P < .01$) for the high and low quality groups respectively. Expressible juice expressed as square inches of wetted area for a 2 g sample was 9.02 and 10.57 for high and low quality groups respectively. All those values verify previous Kentucky work that characterized hams of the two types.

Table 1.—Physical Characteristics of Hams

Item	High Quality Mean	Low Quality Mean
Myoglobin[a]	1.59**	0.68
pH[b]	5.94**	5.43
Press juice,[c] in.^{2}	9.02	10.57

a/ Expressed as mg/g fresh meat.
b/ Taken approximately 72 hr post slaughter on gluteus medius muscle.
c/ Square inches of wetted area obtained by pressing 2 g of gluteus medius muscle with 50 lb wt for 5 min.
**$P < .01$

Weight loss of the two groups differed significantly (P .01), as shown in Table 2.

Table 2.—Weight Loss of Hams (Percent)

Period	High Quality	Low Quality
During cure	4.50**	7.13
After smoking	10.28**	13.68
After aging 3 months	24.35**	28.78
After aging 5 months	28.20**	32.95

**$P < .01$

At each succeeding weigh period the difference in weight loss became greater, being 2.63, 3.40, 4.43, and 4.75 percentage points after curing, smoking, aging 3 months, and aging 5 months respectively. This suggests that the water-holding capacity continued to be less even during the aging period.

As noted in the experimental procedures section, exudate was collected from the hams during holding and transporting the hams, from the time they were selected to the time of their delivery to the Meats Laboratory, approximately 24 hr later. Eight of the low quality hams produced enough exudate to be analyzed. No attempt was made to quantitate the exact amount of protein loss owing to inaccuracies in collection. However, the samples collected from the eight PSE hams ranged from 10.2 to 17.3% protein (N X 6.25). Further work is being done to quantitate these losses.

All exudate was collected during the curing process for each group of hams but not on individual hams, so no statistical tests were applied. Amounts were collected and weighed at the second and third application of cure and at the end of curing (Table 3). The exudate was analyzed for protein and expressed

Table 3.—Exudate and Protein Losses During Curing

	Exudate, lb				Protein, %[a]			Protein
	Period[b]				Period			Loss,
Quality	1	2	3	Total	1	2	3	g
High	6.2	7.0	11.4	24.6	1.62	1.48[c]	1.35	162
Low	11.0	10.6	13.6	35.2	2.14	1.92[c]	1.70	303

a/ This assumes that the density of the brine exudate was 1.20.
b/ 1 = At second cure application; 2 = at third cure application; 3 = before salt equalization.
c/ Determined by interpolation.

as g protein per 100 g exudate, assuming the briny exudate had a density of 1.20. Protein per 100 g ranged from 1.35 in the last collection from the high quality group to 2.14 in the first colkection of the low quality group. Not only did the low quality hams lose more weight each time, they also lost considerably more protein.

Subjective visual observation of the cut surface of the hams showed that the high quality hams were darker, as 11 high quality hams were scored red or dark red and one light red, while 6 low quality hams were scored red and 6 light red. There were no appreciable differences in general appearance as the high quality hams had 8 excellent and 4 good scores while the low quality hams had 8 excellent, 3 good and one fair score. Most scored typically aged on aroma.

Palatability and tenderness scored after 5 months aging are shown in Table 4. The palatability panel did not significantly differentiate between the hams for either tenderness, flavor, saltiness or overall satisfaction although there was a tendency toward scoring the high quality group lower on tenderness and higher on flavor. When subjected to shear tests, however, the semimembranosus (SM) was more tender for the low quality hams, with no difference for the semitendinosus (ST) or biceps femoris (BF). The difference was significant at the 0.01 level for the conventional Warner-Bratzler shear and at the 0.05 level for the Instron mounted shear. This agrees with Fox et al. (1970) who found that the SM but not the ST or BF was more tender in low quality hams.

Table 4.—Palatability and Shear Data

Item	High Quality	Low Quality
Tenderness[a]	5.25	5.47
Flavor[a]	6.63	6.29
Saltiness[a]	6.32	6.25
Overall satisfaction[a]	6.27	6.17
W-B Shear,[b] SM	33.9**	22.4
W-B Shear,[b] ST	22.4	24.2
W-B Shear,[b] BF	19.4	16.9
Inst. Shear,[b] SM	30.4**	24.4
Inst. Shear,[b] ST	23.5	21.1
Inst. Shear,[b] BF	20.9	24.0

a/ Based on a 9-point hedonic scale.
b/ Lb force to shear a one-inch core.
**P < .01. * P < .05 between qualities.

A comparison of muscle tenderness was made. When values both for quality groups and both shear devices were combined, Duncan's multiple range test showed that the BF was most tender and SM least tender. The difference between BF and SM was highly significant, between ST and SM significant, with no significant difference between BF and ST.

Correlations between pH, expressible juice, myoglobin and other traits are shown in Table 5. pH was correlated with myoglobin ($P < .01$) and shear values for the SM ($P < .01$). This verifies the fact that high quality hams with higher pH values had less tender SM muscles. pH was negatively correlated ($P < .01$) with weight loss at the different periods. Expressible juice was negatively correlated with shear values of all muscles, the differences being significant ($P < .05$) for the BF using the WB shear and for the SM and ST ($P < .01$) using the Instron shear. This suggests that hams with more expressible juice are likely to be more tender when dry-cured and aged than those with less expressible juice. Expressible juice was positively and significantly ($P < .01$) associated with weight loss. Myoglobin was significantly ($P < .01$) associated with shear values of the SM and negatively ($P < .01$) with weight loss of the different periods. Of the three measures used, myoglobin gave the highest correlations, with shear values and weight loss indicating its usefulness for predicting there were no significant relationships between either of the three traits and palatability scores.

Table 6.—Tenderness of Different Muscles[a]

Biceps femoris	Semitendinosus	Semimembranosus
18.0[b]	22.4[c]	27.7[cd]

[a] Lb force to shear a one-inch core.
[b] Diff sig., $P < .01$.
[c] Diff sig., $P < .05$.

Table 5.—Correlations Between pH, Expressible Juice and Myoglobin and Various Traits

Trait	Exp. juice	MYO	Shear Values						Palatability Scores				Weight Loss			
			W-B SM	W-B ST	W-B BF	Inst. SM	Inst. ST	Inst. BF	Tend	Flavor	Saltiness	O.S[a]	Cured	Smoked	2 Mo.	5 Mo.
pH	-.34	0.69**	0.56**	.06	-.05	0.52**	-.14	-.24	0.03	0.08	0.02	0.03	-.51**	-.57**	-.45**	-.38**
Expressible juice		-.64**	-.39	-.33	-.46*	-.56*	-.54**	-.19	0.30	-.26	-.34	-.11	0.55**	0.62**	0.60**	0.60**
Myoglobin			0.78**	0.33	0.38	0.57**	0.34	-.06	-.38	0.20	-.32	-.05	-.71**	-.78**	-.75**	-.73**

[a/] Overall satisfaction.

EFFECTS OF CASTRATION ON OVINE NEUTRAL LIPID AND PHOSPHOLIPID DEPOSITION

J. D. Crouse, James D. Kemp, J. D. Fox, D. G. Ely and W. G. Moody

Fourteen ram lambs and fifteen wether lambs, castrated prior to one week of age, were weaned at 40 lb each and fed a growing-finishing ration until they were slaughtered at 100 lb. Carcasses were chilled 48 hr, evaluated and graded. The right side (including bone) was ground and samples obtained and analyzed for total lipid and fatty acid (F.A.) content. F. A. determinations (on the left side) were also obtained on the perinephric, subcutaneous and lean muscle (longissimus) neutral lipid and phospholipid fractions. Data were analyzed by least-squares analysis of covariance with quantity of lipid extracted and seasons used as covariates.

No differences between rams and wethers were found in overall conformation, leg conformation, maturity or firmness. Feathering values were the same for both treatments, however, the wethers had more fat streaking than the rams. The overall grade for wethers, Prime, was significantly higher than that of rams, Choice +. Subcutaneous and perinephric F. A. data are summarized in Table 1. Ram carcasses contained greater quantities of unsaturated F. A. C18:2 and C18:3 with decreased quantities of saturated C18:0. Perinephric adipose tissue F. A. values had a similar trend. Greater quantities of C18:2 and C18:3 with concomitant decreased quantities of C16:0 were observed in the ram carcasses.

Table 1.—Effects of Castration on the Subcutaneous and Perinephric Adipose Tissue Fatty Acid Composition[a]

	Subcutaneous			Perinephric		
	Wethers	Rams	S. E. [2b]	Wethers	Rams	S. E. [2b]
No.	15	14		15	14	
Fatty Acid	%	%		%	%	
C8:0	0.7	0.8	0.31	0.7	0.7	0.38
C14:0	3.3	3.4	2.00	2.3	2.1	0.13
C16:0	23.8	22.9	10.53	20.3*	18.2	5.60
C16:1	3.0	3.5	0.73	2.0	2.4	0.20
C17:0	2.9	3.0	0.46	1.9	2.0	0.16
C17:1	1.5	1.6	0.33	0.7	0.8	0.19
C18:0	17.2*	15.0	6.56	25.6	25.1	21.34
C18:1	39.8	38.6	6.10	36.2	37.0	11.66
C18:2	5.6**	7.5	1.16	6.0**	7.6	0.65
C18:3	2.8**	3.7	0.31	2.6	3.3	0.34

[a] Means adjusted for amount of lipid present and seasons of the year.
[b] Least-squares error mean square with 54 d.f.
*Significant at the 5% probability level.
**Significant at the 1% probability level.

F. A. values for the carcasses (Table 2) closely paralleled values observed for the subcutaneous and perinephric samples with larger quantities of unsaturated C18:2 present in the ram carcasses.

The C18:2 component of the neutral lipid fraction of the lean muscle was greater in the ram carcasses. The rams also contained smaller quantities of F. A. C16:0. Castration did not affect the even-carbon fraction of the phospholipid fraction. Marked differences in F. A. content were observed between the neutral lipid and phospholipid fractions of the lean sample. The phospholipid fraction was observed to contain greater quantities of the unsaturated fatty acids C17:1, C18:2 and C18:3 with decreased quantities of C16:0 and C18:1 in comparison to the neutral lipid fractions.

Table 2.—Effects of Castration on Whole Carcass Lipid Fatty Acid Composition[a]

	Wether	Ram	S.E. [2b/]
No.	15	14	
Fatty Acid	%	%	
C8:0	0.4	1.5	2.22
C14:0	3.4*	2.9	0.32
C16:0	24.0	23.4	8.93
C16:1	3.0	3.1	0.60
C17:0	3.1	2.0	8.93
C17:1	1.2	1.0	0.29
C18:0	16.2	17.1	4.27
C18:1	42.0*	39.1	8.21
C18:2	5.2**	6.7	1.19
C18:3	2.5	2.8	0.42

a, b, *, **/ See Table 1.

Table 3.—Effects of Castration on the Fatty Acid Composition of the Neutral Lipid and Phospholipid Fractions of Lean Muscle[a]

	Fraction					
	Neutral Lipid			Phospholipid		
	Wethers	Rams	S.E. [2b/]	Wethers	Rams	S.E. [2b/]
Fatty Acid	%	%		%	%	
C8:0	2.5	4.4	5.70	4.8	4.7	12.90
C14:0	3.0	2.7	0.54	1.5	2.6	4.79
C16:0	26.1*	24.0	4.89	23.2	21.1	11.25
C16:1	4.1	2.2	5.51	2.2	2.4	0.79
C17:0	1.5	2.0	3.86	1.0	2.1	2.29
C17:1	0.6	0.7	0.11	1.7*	0.8	0.65
C18:0	14.3	14.7	3.07	12.5	13.9	20.73
C18:1	41.5	41.8	7.30	31.4	29.3	25.24
C18:2	4.0*	5.1	0.99	17.6	18.4	42.01
C18:3	2.2	2.5	0.16	3.6	4.2	4.97

a, *, **/ See Table 1.
b/ Least-squares error mean square with 19 d. f.

EFFECT OF STORAGE TEMPERATURE ON SHELF LIFE OF FRESH PORK SAUSAGE

James D. Kemp and B. E. Langlois

Fresh pork sausage was made from unchilled freshly slaughtered pork carcasses at two federally inspected meat processing plants.[1] It was stuffed into plastic bags and chilled to a temperature of approximately 34°F within a few hours. The following day, sausage from each plant was delivered to the University and placed into three temperature groups for storage. Group I was stored at 35°F. Group II was stored at 35°F for one week and at 45°F thereafter. Group III was stored at 45°F. Weekly observations were made for color and aroma. Palatability tests were conducted initially and at weekly intervals or until a particular group developed off-odors. Microbiological analyses were made initially

for total and psychrophilic counts and for numbers of coliform, staphylococci, salmonellae, lactic acid bacteria, Clostridium perfringens and yeasts and molds, and at weekly intervals for total and psychrophilic counts.

Observations for odor and color revealed that the 45°F Group (III) had a slight off-odor and one brand had a slightly grayish color after 2 weeks' storage, while the 35-45°F Group (II) had an off-odor after 3 weeks. The 35°F Group (I) was normal in color and aroma after 5 weeks' storage at which time the study was terminated.

Table 1 gives the results of the organoleptic tests. Since there were no significant differences between brands the scores for brands were combined for each group.

Table 1.—Organoleptic Results—Storage of Sausage

Group No.	Storage Temp. °(F)	Storage Time (Wk)	Color	Aroma	Flavor[a]
All		Initial	Normal	Normal	7.2
I & II	35	1	Normal	Normal	6.9
III	45	1	Normal	Normal	6.6
I	35	2	Normal	Normal	6.6
II	35 - 45	2	Normal	Normal	6.0
III	45	2	Sl. gray	Off-odor	---
I	35	3	Normal	Normal	5.6
II	35 - 45	3	Normal	Off-odor	---
I	35	4	Normal	Normal	7.0
I	35	5	Normal	Normal	7.2

[a] Based on a 9-point hedonic scale.

After one week storage both the 35°F Groups (I & II) and the 45°F Group (III) scored only slightly lower than initially. After 2 weeks the 45°F Group (III) was not tasted because of an off-odor. The 35-45°F Group (II) scored slightly lower than the initial score but was still satisfactory. After 3 weeks the 35-45°F Group (II) was not tasted because of off-odor. The 35°F Group was still satisfactory, but had an unexplained lower score. The scores after 4 and 5 weeks' storage were approximately equal to the initial score, indicating that the shelf-life of the fresh pork sausage was at least 5 weeks if stored at 35°F.

Except for total counts, the results obtained on initial analysis of the sausage were similar for the two brands. Storage at 45°F (Group III) resulted in a rapid increase in numbers of bacteria after 1 week, resulting in spoilage by the second week. Group II (35-45°F) did not increase in numbers during the one week storage at 35°F, but increased rapidly when stored at 45°F. As a result, spoilage occurred by the third week. The number of bacteria in Group I (35°F) remained fairly constant until the third week at which time an increase occurred. At the end of 5 weeks, the number of bacteria were increasing rapidly; however, the sausages were still satisfactory in respect to organoleptic criteria.

EFFECT OF TEAT DIP ON THE CHARACTERISTICS OF STAPHYLOCOCCI ISOLATED FROM THE BOVINE UDDER

Lana Sue Weckbach and B. E. Langlois

Comparisons were made between staphylococci isolated from the foremilk from teats treated with a post-milking teat dip[1] and those from untreated teats. This was done to determine if some of the characteristics used to identify and classify staphylococci were affected by the teat dip.

[1] Bovadine - 10,000 ppm non-irritating titratable iodine.

The 303 isolates were subjected to 68 tests commonly used to identify and classify staphylococci. The results were placed on IBM data cards, and the isolates from the treated teats and those from the untreated teats were compared by the method of numerical taxonomy.

Results obtained from the most common tests used to identify staphylococci are given in Table 1.

Table 1.—Percent of Isolates from Treated and Untreated Groups Positive for Characteristics Used to Identify Staphylococci

Characteristics	Treated (%)	Untreated (%)
Catalase	95.0	94.0
Coagulase	89.1	95.7
DNase	88.2	91.3
Phosphatase	77.3	88.0
Lecithinase	95.0	95.7
Protease	41.2	27.7
Lipase	82.4	87.0
Gelatinase	51.3	38.0
Urease	86.6	89.7
Lysozyme	80.7	92.9
Voges-Proskauer	88.2	90.8
Mannitol (anaerobic)	79.0	65.8
Glucose (anaerobic)	95.8	89.1

The treated group consisted of 119 isolates and the untreated group 184 isolates. On comparing the results for the two groups, a general trend emerged in which the isolates in the treated group had a lower percentage of characteristics which often have been used as indicator of pathogenicity such as DNase, coagulase, lipase, and lysozyme. This difference was found by the Chi-square test to be significant (P .05) for all except DNase. A significant decrease also was found in the production of phosphatase. These results would seem to indicate that the post-milking teat dip reduced the number of pathogenic staphylococci.

The reverse situation occurred when other characteristics in which differences occurred were examined. A significant increase was found in the ability of the isolates in the treated group to ferment mannitol and glucose anaerobically and to produce gelatinase and protease.

The majority of the catalase positive isolates were found to be more closely related to Staphylococcus aureus than to Staphylococcus epidermidis.

ANIMAL NUTRITION SECTION

RECYCLING ANIMAL WASTE THROUGH POULTRY I. DRIED RUMEN RESIDUE

J. J. Begin and J. D. Fox

Each year approximately 1,200,000 tons of rumen residue are produced in the United States as the result of commercial slaughter operations. Disposal of this material leads to pollution of water and soil, is expensive, and presents some very serious problems to the meat packing industry.

Few research results have been published relating to the utilization or disposal of rumen residue. Although industry has conducted limited research on disposal of rumen residue, no satisfactory method for disposal has been developed.

During the past year three chick experiments and a preliminary laying hen trial have been conducted to determine the nutritional value of dried rumen residue as a poultry diet ingredient.

The dried material used in all experiments was obtained from a commercial packing plant. The material was reground and assayed for moisture, protein, ether extract and ash. The analytical results were as follows: moisture, 17.93%; protein, 16.87%; ether extract, 16.72% and ash, 5.80%.

CHICK EXPERIMENTS

The three chick experiments were designed to evaluate biologically dried rumen residue as an ingredient for poultry diets. In each experiment 2 replicate lots of 10 chicks each were fed either the basal diet or the basal diet with 20% dried paunch material substituted for 20% cerelose. This substitution was necessary for the procedure used for assaying the rumen residue for metabolizable energy content. The experimental diets are shown in Table 1. Each experiment was conducted for 4 weeks with New Hampshire X Columbian male chicks. Chromic oxide was added to the diets as an index material, and at the termination of each experiment excreta samples were collected from each pen. The excreta samples, together with a sample of the diet, were analyzed for moisture, gross energy, chromic oxide and nitrogen by the usual laboratory procedures. From these data the nitrogen-corrected metabolizable energy value for each diet was determined. The metabolizable energy content of the dried rumen residue was calculated from the data by use of the following formula:

$$\text{ME per g of rumen residue} = 3.64 + \frac{\text{ME per g test diet} - \text{ME per g basal diet}}{\text{g of test material/g test diet}}$$

Table 1.—Composition of Basal Diet

Ingredient	%
Ground yellow corn	31.05
Dehulled soybean meal	37.50
Cerelose	25.00
Corn oil	2.00
Limestone	1.00
Dical. phosphate	2.25
Salt	0.25
Vitamin mix (Dawes)	0.30
Chromic oxide	0.30
M. H. A. (90%)	0.15
Total	100.00

The mean data from all three chick experiments are summarized in Table 2.

Table 2.—Effect of Dried Paunch Residue on Chick Performance

Criteria	Basal Diet	20% Rumen Residue
Weight gain, g	356	378
Feed intake, g	659	725**
Diet M. E. value, Kcal	3.22**	2.96
M. E. intake, Kcal	2125	2149
Protein intake, g	145	186**
Wt. gain/feed intake, g	0.541*	0.521
Wt. gain/M. E. intake, g	.168	.176
Nitrogen retention, %	61.58*	54.72
Protein intake/g body wt., mg	363	442**

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

The data show very clearly that this particular dried rumen residue sample can be used as an ingredient in chick diets. The results indicate that rate of weight gain was similar on both diets. There was a significant difference in both feed intake and protein intake between the two diets. The increased feed and protein consumption observed with chicks fed the dried rumen contents was the result of a significantly lower dietary metabolizable energy content. This low energy value of the diet containing 20% dried rumen residue was to be expected since the material assayed 2.34 Kcal of M. E. per gram and since it replaced cerelose with a 3.64 Kcal of M. E. per gram energy value. The birds on both diets consumed approximately the same amount of energy, thus the increased feed intake was necessary for the chicks to obtain the required number of calories. The feed efficiency data show that the birds fed the basal diet utilized their feed more efficiently and the observed difference was significant.

The energy efficiency data show that both diets were approximately equal, indicating that the energy derived from the dried rumen residue was usable. The protein efficiency ratio shows a highly significant difference between the two diets, with the birds fed the lower protein basal diet being the more efficient. This indicates that the dried rumen diet contained protein in excess of that required for this level of growth. This is also reflected in the nitrogen retention data which clearly show a significant difference between the two diets. The chicks fed the basal diet retained more of the dietary nitrogen.

These results show that this particular sample of dried rumen residue will support normal growth, is palatable, and has no deleterious effects on health of growing chicks. Its relatively low energy level results in a greater feed intake and consequently lower feed utilization.

PRELIMINARY LAYING EXPERIMENT

The laying experiment involved 20 hens, housed in individual cages. Ten hens were fed a diet containing 10% dried rumen residue and 10 hens, serving as the controls, were fed a standard 16% laying diet. The birds were fed the experimental diets for five 28-day periods. Egg production, feed intake, and egg weight records were kept. The results are shown in Table 3.

Table 3.—Effect of Feeding Dried Rumen Paunch to Laying Hens

	Diet 69-7 Control	Diet 69-11 20% Dried Paunch
Eggs per hen day, %	70.28	81.79
Feed per hen day, g	150.20	133.91
Egg weight, g	60.28	61.49
Egg yield* per hen day, g	42.40	49.41
Egg yield* per gram feed, g	0.282	0.373

*Egg yield is the number of eggs laid times the mean egg weight.

The results indicate that hens tolerate at least 10% dried rumen residue in the diet without any deleterious effects. Excellent egg production and feed efficiency were observed over the five 28-day periods. Feed intake data indicate that the diet containing the dried rumen residue was palatable. No effect was noted on egg weight.

RECYCLING ANIMAL WASTE THROUGH POULTRY II. DRIED POULTRY MANURE

Utai Pisone and J. J. Begin

During recent years the development and growth of the poultry industry have resulted in the production of vast amounts of manure, and its disposal has become a major concern from both a health and economic view point. Solutions must be found for utilizing or disposing of this waste material. Methods suggested include: spreading on land, anaerobic digestion, methane production, composting, incineration and dehydration; however, no one method has been found to be universally acceptable. The possibility of recycling manure back through animals in such a manner as to recover some of the wasted nutrients would reduce the waste management problem as well as lower ration costs.

EXPERIMENTAL PROCEDURE

One-hundred Cashman strain S.C. White Leghorn pullets, 20 weeks of age were weighed and randomly assigned to individual cages in a windowless cage laying house. The pullets were grouped in such a manner so that there were 20 groups consisting of 5 hens each. The 4 replicates of 20 pullets each were randomly assigned to five experimental diets which contained 0, 5, 10, 10 and 30% dried hen manure. Composition of the experimental diets and their analyses are shown in Table 1. The manure was obtained from laying hens maintained on a standard laying diet. The manure was dried, ground and the feathers removed by screening. Feed and water were supplied ad libitum. Artificial lights were used to provide a minimum of 16 hr of light per day. No vaccination or medication program was used.

The experiment was of a duration of eight 28-day periods. Feed intake, egg numbers, egg weights, and egg quality measurements were obtained each 28 days. Weight changes of sample birds were recorded at the end of the experiment. Mortality was recorded as it occurred.

RESULTS

The treatment effects for egg production, feed intake, egg size, productive efficiency, body weight changes and mortality are shown in Table 2.

Table 1.—Composition of Experimental Diets

Component	Diet A	B	C	D	E
Basic mixture*	90.25	84.00	78.30	66.25	55.04
Ground limestone	6.00	6.00	5.76	5.00	3.21
Dical, phosphate	3.00	2.25	1.44	---	---
Vitamin mix (Dawes)	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25
Lard	0.00	2.00	3.75	8.00	11.00
Dried poultry manure	0.00	5.00	10.00	20.00	30.00
Total	100.00	100.00	100.00	100.00	100.00
ANALYSIS					
Protein, %	16.2	16.0	16.1	16.1	16.2
Calcium, %	3.2	3.3	3.3	3.2	3.4
Phosphorus, %	0.9	0.9	0.9	0.8	0.9

*Basic mixture contained 66% corn, 11% wheat middlings, 20% dehulled soybean meal and 3% alfalfa meal.

The data indicate that laying hens can utilize up to 30% dried poultry manure in their diet without any adverse effects on egg production, appetite and feed intake, egg weight, productive efficiency, body weight changes or mortality. Statistical analysis of the data shows that none of the observed differences in productive performance were significant. Even though the higher levels of manure in the diet tend to depress egg production and efficiency, the results indicate that manure can supply usable protein as well as provide calcium and phosphorus to the diet.

Table 2.—Effect of Feeding Dried Poultry Manure on the Productive Performance of Laying Hens

Item	Percent Dried Manure				
	0	5	10	20	30
Hen day production, %	70.19	73.99	70.81	66.50	66.14
Hen day feed intake, g	118	125	117	112	119
Egg weight, g	60.6	59.8	59.6	60.3	59.3
Grams of egg per hen day, g	42.5	42.5	42.2	40.2	39.2
Productive efficiency, g	0.362	0.356	0.359	0.357	0.329
Body weight changes, g	305	546	387	232	213
Mortality, %	25	0	25	10	10

*Grams of egg/gram of food.

EQUINE CECAL BACTERIAL GROWTH AS MEASURED BY ^{35}S

A. A. Wysocki, J. P. Baker and R. S. Fulghum

Information is very limited on the role of equine cecal bacteria. Of particular interest are the contributions made by these bacteria to the nutrition of the horse and the factors which influence bacterial growth in the cecum. Studies have been initiated to investigate these points.

A series of in vitro incubations was carried out with equine cecal bacteria to determine the extent of incorporation of ^{35}S from $Na_2{}^{35}SO_4$ into the bacterial cell and to determine if ^{35}S incorporation could be used as a measure of bacterial growth in vitro. The medium consisted of 666 ml sterile horse cecal fluid, 13.80 g glucose, 2 g soluble starch, 1.08 g urea, 4.33 g mineral salts mixture and 0.06 ml n-valeric acid. Each flask contained 100 ml of medium innoculated with 2 ml of a washed cecal bacterial suspension containing 10 g bacteria (wet weight) per 100 ml of suspension. Growth at various time intervals was measured gravimetrically either by weighing the precipitate after centrifuging at 22,000 x gravity for 15 min., or by precipitating 20 ml of the fermentation mixture with 5 ml of 10% sodium tungstate and 5 ml of 1.07 N sulfuric acid, centrifuging as before and then weighing. In addition, growth was estimated by measuring the percent of ^{35}S incorporated into the cellular fraction of the fermentation mixture.

The cell yield at 5, 10, 15, 20, 24, 36 and 42 hr after innoculation was increased 4, 33, 62, 71, 93, 99 and 115%, respectively. At the same times, the percent increase in ^{35}S in the protein fraction was 165, 188, 208, 235, 477 and 546%, respectively.

The more rapid incorporation of ^{35}S as opposed to weight increase is probably due to the short length of time necessary to build up the label in the sulfide pool from which amino acids are synthesized. It appears that equine cecal bacteria metabolize inorganic sulfur in the same manner as rumen bacteria and that $Na_2{}^{35}SO_4$ can be used to measure equine cecal bacterial growth in vitro.

ROLE OF THE CECUM IN PROTEIN NUTRITION OF THE EQUINE

J. P. Baker, Sandi Lieb, B. H. Crawford, Jr.
and D. D. Kratzer

It has been suggested that the population of bacteria found in the lower digestive tract of the equine serves an important role in protein nutrition of the horse, though comparatively little research

has been done in this area. Some studies have been completed which provide some information on this problem.

Two experiments were conducted using cecal-fistulated, portal-catheterized ponies. In both trials two ponies were used in a cross-over design in which the treatments were administered by cecal infusion and the responses measured by changes in portal blood plasma levels of ammonia, urea nitrogen, total protein, and free amino nitrogen. The ponies had water and wheat straw ad libitum throughout the trials. During the 2-day infusion periods one pony received the treatment solution, while the other was given a control solution and portal samples were drawn at regular intervals. Following an infusion period the treatments were discontinued, the ponies allowed an adjustment period, then switched to the opposite treatment and the infusions repeated. In the first trial the treatment solution was urea with a cerelose solution as the control, and in the second trial a gelatin solution was given with water serving as the control.

Results of the trials were similar, with sharp increases in portal plasma NH_3 and urea N following infusion of either nitrogen source with no appreciable change in portal plasma protein or free amino N. These results provide further evidence that the lower gut does not play a major role in the protein nutrition of the equine.

STUDIES ON EQUINE CECAL BACTERIA

Sally McCreery, R. S. Fulghum, and J. P. Baker

Information is very limited on the role of equine cecal bacteria. Of particular interest are the contributions made by these bacteria to the nutrition of the horse and the factors which influence bacterial growth in the cecum. Studies have been initiated to investigate these points.

Preliminary work has begun on the numbers and types of bacteria found in the equine cecum. Results from one pony reveal direct microscopic clump counts (DMCC) ranging from 1×10^{10} to 2.3×10^{11}. DMCC appear to be highest 6 hours after feeding. DMCC varied with the fluidity of the cecal contents. Colony counts were made, using the anaerobic roll tube technique of Hungate as modified by Moore (V.P.I. Anaerobe Laboratory). Highest counts were obtained on a medium containing 50% (v/v) horse cecal fluid additive ("H" medium). "H" medium supported the growth of 3.9×10^9 organisms per ml (14 percent of DMCC) of the samples of cecal contents used. The "E" medium of Moore supported 3×10^9 organisms per ml of 10% of DMCC. Proteolytic counts were made, using variation of "H" medium with sterile skim milk.

Clear zones surrounding colonies of proteolytic bacteria were found regularly only in the 10^{-6} or lower dilutions. Counts of proteolytic colonies averaged 5×10^6 per ml of cecal contents. Isolations from 10^{-8} dilutions yield a flora of which approximately 45% are strictly anaerobic bacteria. Isolates are being characterized, using the techniques of the V.P.I. Anaerobe Laboratory. These date provide information useful in determining the role of the lower gut in the nutrition of the equine.

NUTRIENT DIGESTION AND INDICATOR RETENTION BEFORE AND AFTER FISTULATION IN HORSES

R. E. Pulse, J. P. Baker, G. D. Potter,
W. J. Hudson and J. K. Goodspeed

Only limited data concern the effects of cecal fistulation of horses upon nutrient digestibility and rate of passage. Information also is limited on the comparative values of chromic oxide and polyethylene as external indicators in digestion and rate of passage studies in horses. This report describes nutrient digestion and indicator horses.

Three Thoroughbred geldings were used in these experiments. Four identical trial periods were conducted—two before fistulation and two after fistulation. Each trial period consisted of an 8-day preliminary feeding period followed by a 6-day digestion trial. The horses were fed a complete pelleted ration containing 0.206% Cr_2O_3 and 2.65% polyethylene during each preliminary and digestion trial. At the end of each digestion trial the ration with indicators was replaced with an identical ration containing no indicators, and fecal collections were made for a 5-day period to measure indicator retention expressed as a percent of the mean levels observed during the digestion trial period. Total fecal

collections were made with a harness and bag-type collection apparatus. Fecal samples were taken at 12-hr intervals during the digestion trials and at 6-hr intervals during the retention trials. All samples were frozen for later analyses. Digestion coefficients were determined for dry matter, crude protein, fat and crude fiber by three methods; total collection and indicator methods using chromic oxide and polyethylene.

The mean digestion coefficients for the various nutrients as calculated by the three methods can be seen in Table 1. No difference was found in method of calculating digestibility but a significant increase in fat and fiber digestion ($P < .01$) after fistulation was found. A graphic comparison of indicator retention before and after fistulation can be seen in Fig. 1. After 5 days of fecal collection there was less than 10% of the indicators retained in all cases.

The increases in fat and fiber digestion after fistulation could possibly be due to increased retention time after fistulation as shown in Fig. 1.

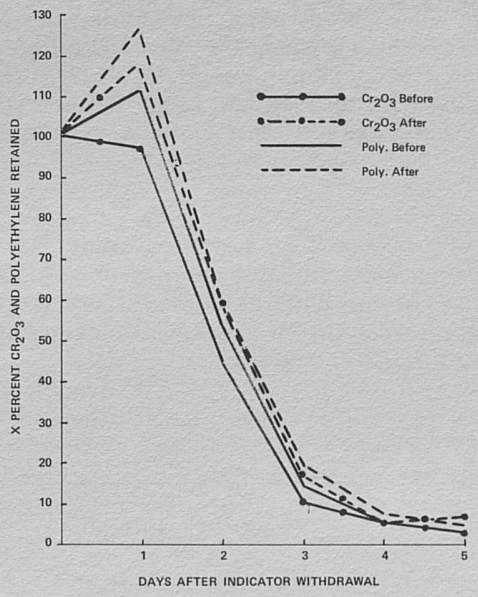

Fig. 1.—Effects of fistulation upon retention of Cr_2O_3 and polyethylene.

Table 1.—Digestion Coefficients Before and After Fistulation In Horses as Calculated by Three Methods

		Digestion Coefficients			
Period	Method	Dry Matter	Crude Protein	Ether Extract	Crude Fiber
Before fistulation	Total	60.48	64.14	51.10	39.54
	Cr_2O_3	59.95	65.09	54.82	38.59
	Poly	57.19	62.91	51.64	34.55
	x	59.21	64.05	52.52[a/]	37.56[a/]
After fistulation	Total	62.37	63.03	66.59	45.71
	Cr_2O_3	61.28	62.23	65.24	44.15
	Poly	61.12	62.02	65.44	43.92
	x	61.59	62.43	65.76[b/]	44.59[b/]

[ab/] Means in the same column with different subscript letters differ significantly ($P < .01$).

EFFECTS OF ESTIMATED NET ENERGY AND PROTEIN CONTENT OF FEED ON MILK YIELD AND COMPOSITION DURING THE EARLY STAGE OF LACTATION

C. M. Enlow, R. W. Hemken, Don R. Jacobson and H. H. Van Horn

Thirty-six lactating Holstein and Jersey cows were fed complete rations of corn silage and grain containing two energy levels high--60% of dry matter (D. M.) from grain and 40% of D. M. from silage and low—33% of D. M. from grain and 67% of D. M. from silage and two protein levels (14 and 10% of the complete ration on a D. M. basis) in a 2 x 2 factorial arrangement. The foregoing complete rations each contained one of four ground shelled corn and soybean meal grain mixes of different crude protein contents in order to achieve the desired protein-energy combinations. These grain mixes, ranging from 12% crude protein to 28. 2% crude protein on D. M. basis, were hand mixed with the silage at time of feeding to form the complete ration.

Animals were blocked by breed and age and assigned to a 6-week standardization period within one week after calving. During standardization, all cows were fed a high-energy 12% protein ration, individually fed twice daily, and refusals weighed once each day. The experimental period consisted of a 13-week period of individual feeding with milk weight being taken at each milking. A composite sample of morning and night milk was taken once weekly and analyzed for fat and solids not fat. Feed samples were analyzed monthly for dry matter and protein, while estimated net energy values were taken from Morrison's tables.

This study is the first period of a larger 2 x 3 factorial study. The original experiment, now nearing completion, contains two 13-week experimental periods in which there is a total of six treatments. The treatments consist of two protein levels combined with an energy feeding sequence of either holding the estimated net energy constant over the two periods or changing it from high energy to low energy. Table 1 gives the treatments for the entire project.

Table 1. —Treatments

Treatment		Period 1	Period 2
1	14% protein	H	H
2	14% protein	H	L
3	14% protein	L	L
4	10% protein	H	H
5	10% protein	H	L
6	10% protein	L	L

H = High estimated net energy content.
L = Low estimated net energy content.

Estimated net energy was used as a covariate in calculating the adjusted treatment means for the main effects and interactions by dry matter consumed, estimated net energy consumed, protein consumed, solids corrected milk produced, % milk fat, % S. N. F. and body weight changes shown in Table 2.

As shown in Table 2, cows receiving the higher level of protein (14%) consumed more estimated net energy, produced more milk, and gained more in body weight than the cows receiving the lower level of protein (10%). While the amount of milk produced was increased, the difference in milk composition between the two treatments was not significant. The results indicate the benefits of feeding a total ration of 14% protein rather than 10% protein during this period of 7 to 19 weeks following calving.

Although cows on the high-energy ration consumed significantly more net energy and protein and gained more body weight there was no significant differences in amount of milk produced or percent milk fat. Cows on the high-energy ration gained more in body weight and their milk was significantly higher in solids-not-fat content.

Table 2 shows that the high-energy, high-protein combination gives superior milk production and results in higher body weight gains than any of the other three combinations. The high-protein, low-energy ration resulted in the next highest milk production; however, the cows on this ration consumed significantly less dry matter and protein and gained less weight, which again suggests that appetite may have been depressed. The decrease in protein level resulted in a corresponding decrease in protein intake which may be responsible for the lower milk production instead of the lower energy content. This may also be partly substantiated by noting protein and dry matter consumption of cows on the remaining rations. All were significantly lower in dry matter and protein intakes and in milk production than those of the high-protein group, while at the same time there was a trend for increasing milk production with increasing protein consumption.

Table 2.—Feed Intake and Cow Performance During First Period

Treatments and Main Effect	Dry Matter Intake	Estimated Net Energy Intake	Protein Intake	Solids Corrected Milk	Milk Fat	Solids Not Fat	Body Weight Change
	(kg)	(Mcal)	(kg)	(kg)	(%)	(%)	(kg)
14% Prot. - high energy	16.5	29.2	2.37	19.3	4.1	9.24	+33
14% Prot. - low energy	13.8	22.3	1.97	17.7	3.9	8.85	+21
10% Prot. - high energy	13.5	23.9	1.39	15.9	4.0	8.99	-3
10% Prot. - low energy	13.1	21.3	1.42	16.7	4.0	8.92	-4
Main Effects:							
14% Prot.	15.1	25.7	2.17	18.5	4.0	9.04	+29
10% Prot.	13.3	22.6	1.41	16.3	4.0	8.95	-4
High energy	14.9	26.5	1.88	17.6	4.0	9.11	+15
Low energy	13.4	21.8	1.70	17.2	3.9	8.88	+9

ORAL OR ABOMASAL SUPPLEMENTS OF METHIONINE OR METHIONINE HYDROXY ANALOGUE FOR LACTATING COWS

G. D. Hale and D. R. Jacobson

Six mature lactating Jersey cows fitted with abomasal fistulas were employed in a 6x6 latin square design of 4-week periods with nitrogen, methionine or analogue supplements as treatments 1 through 6 nearly isonitrogenous, isocaloric and of similar Ca, P, Mg, S, Na and K content in this order: oral 2% urea, oral DL-methionine (DL-Met), oral D1-alpha-hydroxy-gamma-methyl mercapto butyrate calcium (MHA), abomasally infused DL-Met, and MHA, and oral soybean meal. Corn silage was mixed with the concentrate to provide a diet ratio of 4.3:1.0. Mean nitrogen (N) content of all diet including abomasal infusion dry matter was 1.8%.

All animals were fed ad libitum the first 3 weeks of each period. At the beginning of the fourth week, the cows were placed in metabolism stalls for N and amino acid balance where feed intake was restricted to 90% of the previous 3 week mean. Infusion and oral quantities were similar. Calculated rates were 1.3% and 1.4% for DL-Met and MHA, respectively, of the concentrates as fed. Infusions were made twice daily at 12-hr intervals 2 hr post feeding in 5 minutes.

Mean daily values for treatments 1 through 5 for the third treatment week were, respectively: 4% fat corrected milk 11.1, 10.5, 9.8, 9.0, 9.5, and 10.3 kg; % milk fat, 6.1, 5.6, 5.8, 6.9, 5.4, 5.0; nonfat solids, 0.754, 0.735, 0.680, 0.593, 0.720, and 0.796 kg; dry matter intake, 9.3, 9.4, 7.5, 5.1, 9.0, and 9.8 kg; N balance during the 4th week 0.389, 6.284, 1.326, -15.186, 8.635, and -4.236 g.

ABSORPTION MEASURED BY ARTERIAL-VENOUS DIFFERENCE OF SUGARS, VOLATILE FATTY ACIDS AND AMINO ACIDS IN CALVES FED MILK OR HAY AND CONCENTRATE

C. J. Sniffen, D. R. Jacobson, R. H. Hatton, I. D. Hume, C. E. Miller, and W. A. Tucker

Portal blood flow was measured, employing the principle of Doppler shift and telemetry in nine Holstein bull calves ranging in body weight from 47.2 to 109.2 kg and in age from 40 to 109 days. Calves were fed fresh milk at 8% of body weight daily in two feedings. Immediately after measurement on milk each calf was changed to a dry feed diet consisting of hay and concentrate fed at 20 and 80% of digestible energy requirements. Measurements were taken two weeks after changing. Portal and carotid samples were taken at 0.5 hr before feeding and 0.5, 1.5, 2.5, 4.5, 7.5, and 11.5 hr after feeding for two 12-hr periods while on milk; when the calves were on dry feed samples were taken at 2-hr intervals. Large variation was found between animals in absorption of all metabolites measured. Variations within animals were greater in milk fed calves. Amino acid and sugar absorption was higher on milk and volatile fatty acid absorption was higher in animals on dry feed.

PORTAL BLOOD FLOW IN HOLSTEIN CALVES AND STEERS AS AFFECTED BY POSITION, ACTIVITY, WEIGHT, FEEDING AND DIET

C. J. Sniffen, D. R. Jacobson, I. D. Hume, R. H. Hatton, C. E. Miller, and W. A. Tucker

Portal blood flow was estimated by Doppler shift, employing a Doppler ultrasonic blood flow meter and telemetry. Blood flow was measured in nine Holstein bull calves and four Holstein steers fed milk or hay and concentrate, and two maturity alfalfa hays, respectively, in 26 different experiments. The calves ranged in body weight from 47.2 to 109 kg and the steers from 156 to 230 kg. Blood flow was measured continuously for a period of 2 days, and during the second day blood samples were taken. Blood flow increased after feeding, while position, eating, rumination and day were not significant. Diet was found to alter blood flow. Portal flow (L/hr) was found to be correlated ($r = 0.97$) with body weight (kg) and had the relationship of $y = 2.44 X - 9.87$. Mean flow per animal ranged from 15.1 ml/min/kgBW to 55.1 ml/min/kgBW with a mean of 37.5 ± 7.6 ml/min/kgBW. Different techniques were considered relative to continuous measurements and to conversion of portal blood velocity to volume.

ABSORPTION OF SUGARS, VOLATILE FATTY ACIDS, AND AMINO ACIDS, MEASURED BY ARTERIAL-VENOUS DIFFERENCE IN STEERS ON TWO MATURITY ALFALFA HAYS

C. J. Sniffen, D. R. Jacobson, R. H. Hatton, and I. D. Hume

Portal blood flow was measured continuously for 48 hr, employing the principle of Doppler shift and utilizing telemetry, in 4 Holstein steers, ranging in body weight from 156 to 230 kg and in age from 213 to 332 days in different experiments. Early cut (A) and late cut (B) alfalfa hay from the same field was offered at 90% of ad libitum in two 12-hr feedings. Absorption of metabolites was estimated by portal-carotid difference coupled with portal blood flow. Blood samples were taken at 2-hr intervals for a 24 hr period. Variation within and between animals was large, however, several trends were evident. The maturity of hay did not affect blood flow (A-38.7, vs B-38.9 ml/min/kgBW). Absorption of reducing sugars was greater for the steers on A while the total VFA absorption tended to be lower. Total amino acid absorption was reduced by increasing maturity. This was related to a lower protein intake for the steers on B.

CREEP FEEDING SPRING CALVES ON KENTUCKY BLUEGRASS - LADINO CLOVER OR FESCUE - LADINO CLOVER PASTURE

N. W. Bradley, W. C. Templeton, Jr., D. R. Lovell, J. A. Boling and R. L. Ludwick

A long-term study has been initiated to observe the effects of creep feeding spring- and fall-born calves on either bluegrass-ladino clover or fescue-ladino clover pastures. One hundred and twenty

beef brood cows of the Angus breed are being used in a completely randomized experiment with a 2 x 2 x 2 factorial arrangement of treatments. The factors and levels of each and the number of cows per treatment are shown in Table 1. One-half of the cows are being bred to calve during the last half of February and during March and April, and the other half are being bred to calve during the last half of September and during October and November.

The first and second year's progress reports of the pre-weaning gains of the spring-born calves on the two kinds of pasture and receiving creep or no creep feed are presented in Table 2. The same data of the fall-born calves for the first year are presented in Table 3.

Table 1.—Experimental Design

	Spring Calving		Fall Calving	
	Bluegrass-ladino	Fescue ladino	Bluegrass-ladino	Fescue-ladino
No creep	15	15	15	15
Grain creep	15	15	15	15

Table 2.—Data for Creep Feeding Spring Calves on Bluegrass-Ladino and Fescue-Ladino Clover Pastures, 1969 and 1970

Item	Bluegrass		Fescue	
	No Creep	Creep	No Creep	Creep
		1969		
No. calves[a/]	15	15	15	15
Avg daily gain, lb	1.87	2.11	1.45	1.82
Avg feed/calf daily, lb	----	2.93	----	2.90
Avg feed/lb of gain, lb	----	1.41	----	1.83
		1970		
No. calves[b/]	15	15	15	15
Avg daily gain, lb	1.94	2.09	1.77	2.12
Avg feed/calf daily, lb	----	3.21	----	3.57
Avg feed/lb of gain, lb	----	1.48	----	1.62

[a]Calves were weaned at an average age of 206 days and received creep during the last 172 days.
[b]Calves were weaned at an average age of 208 days and received creep during the last 166 days.

Table 3.—Data for Creep Feeding Fall Calves on Bluegrass-Ladino and Fescue-Ladino Clover Pastures, 1969

Item	Bluegrass		Fescue	
	No Creep	Creep	No Creep	Creep
No. calves[a/]	15	15	15	15
Avg daily gain, lb	1.80	1.83	1.68	1.81
Avg feed/calf daily, lb	----	4.26	----	4.26
Avg feed/lb of gain, lb	----	2.14	----	2.02

[a]Calves were weaned at an average age of 291 days and received creep during the last 197 days.

The winter feed cost of the spring and fall calving cows are presented in Table 4. The preliminary data suggest that the cost of wintering the fall-calving cow is 2 to 2.5 times that of the cost of wintering the spring-calving cow. The bluegrass-ladino and fescue-ladino hay production is shown in Table 5. These values represent the excess forage produced in each of these systems which was harvested as hay.

This is a long-term continuing project, and the results should be considered as a preliminary progress report. Additional data will be presented as collected and summarized.

Table 4.—Winter Feed Intake and Cost of Spring and Fall Calving Cows,[a] 1969 and 1970

Spring Calving		Fall Calving	
1969			
Total feed per cow		Total feed per cow	
80 lb ground shelled corn x 2.5¢/lb @1.40 bu =	$ 2.00	20 lb ground ear corn x 2¢/lb @1.40 bu =	$0.40
2400 lb grass hay x $20/ton =	24.00	150 lb ground shelled corn x 2.5 /lb @1.40 bu =	3.75
		7830 lb corn silage x $10/ton =	39.15
		375 lb alfalfa hay x $30/ton =	5.63
		1170 lb high quality grass hay x $25/ton =	14.62
TOTAL	$26.00	TOTAL	$63.55
1970			
Total feed per cow - Bluegrass pasture		Total feed per cow	
140 lb ground shelled corn x 3¢/lb @1.68 bu =	$ 4.20	60 lb ground shelled corn at 3¢/lb @1.68 bu =	$1.80
1525 lb grass hay x $20/ton =	15.25	480 lb grass hay x $20/ton =	4.80
		5940 lb corn silage x $10/ton =	29.70
TOTAL	$19.45	TOTAL	$36.30
Total feed per cow - Fescue pasture			
140 lb ground shelled corn x 3¢/lb @1.68 bu =	$ 4.20		
1259 lb grass hay at $20/ton =	12.59		
TOTAL	$16.79		

[a]Salt, bone meal, vitamin A and magnesium oxide not included in feed cost.

Table 5.—Bluegrass-Ladino and Fescue-Ladino Hay Production

Item	Spring Calving		Fall Calving	
	Fescue	Bluegrass	Fescue	Bluegrass
Total number acres cut for hay	30.0	30.0	45.0	37.5
Hay produced, ton	46.0	26.0	50.0	36.0
Lb air-dry hay/acre	3067	1733	2222	1920
Number acres grazed	30.0	30.0	15.0	22.5

EFFECTS OF BLIGHTED CORN SILAGE ON BEEF CATTLE

Nelson Gay and N. W. Bradley

A feeding trial involving 32 head of heavy beef calves was conducted to compare the feeding value of blighted corn silage with normal. The blighted silage was purchased from a Fayette County farmer who experienced a yield reduction of about 50% with this particular variety. The control silage was grown on Coldstream and Maine Chance farms and was considered relatively blight free. Approximate composition and grain yields for the silages were:

	% Dry Matter	% Crude Protein	Grain Yield, %
Normal silage	45.1	4.20	-
Blighted silage	41.1	2.93	63

The steers were randomly assigned to two groups of 16 head each and were fed all the corn silage they would consume daily plus a complete protein supplement. Steer performance and feed consumption are shown in Table 1.

Table 1.—Performance and Feed Consumption

	Control	Blighted
Days	56	56
Starting wt, lb	538	530
Ending wt, lb	646	652
ADG, lb	1.93	2.18
Avg daily ration		
Corn silage, lb	30.0	32.5
Supplement, lb	1.2	1.2

Neither feed consumption nor performance was adversely affected by feeding blight-stricken corn silage. In this instance the blighted silage had a higher-than-normal rate of surface spoilage but did ensile adequately. Silage made from more severely blighted corn may well have less feeding value.

PREFORMED PROTEIN SOURCES OF DIFFERENT SOLUBILITY IN STEER RATIONS

R. L. Ludwick, N. W. Bradley, J. A. Boling and R. C. Burris

Protein quality, in general, is believed to be less important in ruminant diets than in those of nonruminants because of the action of the ruminal microflora. However, protein solubility controls to a degree the hydrolytic action of these bacteria. Proteins of low solubility present a greater quantity of intact protein to the gastrointestinal tract than do those of higher solubility. Therefore, a protein of higher quality than bacterial protein would be of more benefit to the host if it by-passed bacterial degradation. The objective of this study was to determine the performance of steers fed protein supplements of varying solubilities. The protein supplements and order of solubility in the rumen from the highest to the lowest were: linseed meal, soybean meal and fishmeal.

Eighty yearling steers of several breeds (Angus, Charolais cross and Herefords) were randomly allotted by breed and weight into eight lots of seven steers and four lots of six steers each. Each lot of steers were randomly allotted to one of the supplements presented in Table 1, resulting in three replications (20 steers) per treatment. Each steer was fed 35 lb of corn silage and 8 lb of supplement daily. Fed at this level, the basal corn supplement (ration 1) contained 84% NRC (1970) requirement for crude protein, while rations 2, 3 and 4 were slightly in excess of the NRC requirement. All rations

were balanced to contain 0.41% calcium and 0.35% phosphorus. The steers were fed these respective rations for 146 days.

Table 1.—Composition of Experimental Supplements[a]

Item	Ration:	Protein Supplement: None 1	Soybean Meal 2	Fishmeal 3	Linseed Meal 4
Ingredient, %					
Corn		96.3	80.3	88.0	75.4
Soybean meal		----	16.2	----	----
Fishmeal		----	----	10.5	----
Linseed meal		----	----	----	21.4
Dicalcium phosphate		1.5	1.2	----	0.8
Limestone		0.7	0.8	----	0.9
Salt		1.5	1.5	1.5	1.5
Chemical composition, %					
Dry matter		88.6	88.5	88.5	88.7
Crude protein		8.0	13.1	14.7	12.2

[a]Four million IU vitamin A added per ton.

The performance of the steers for the 146-day feedlot study are presented in Table 2. The average daily gain of the steers fed the protein-supplemented rations did not differ significantly. However, steers receiving no protein supplement (ration 1) gained 0.31 lb less per day than the average gain of the steers receiving protein supplementation. Feed efficiency was improved 12% by protein supplementation. Feed cost per 100 lb of gain was lowest for the soybean meal supplemented ration ($16.20) and highest for the fishmeal supplemented ration ($18.16).

Table 2.—Performance of Steers Fed Various Protein Supplements[a]

Item	Ration:	Protein Supplement: None 1	Soybean Meal 2	Fishmeal 3	Linseed Meal 4
Number of steers		20	20	20	20
Average weight data, lb					
Initial weight		644	638	641	644
Final weight		972	1,013	1,017	1,014
Gain		328	375	376	370
Daily gain		2.25	2.57	2.58	2.53
Average feed data, lb (As fed)					
Corn		7.54	6.29	6.89	5.90
Linseed meal		-----	-----	-----	1.68
Soybean meal		-----	1.27	-----	-----
Fishmeal		-----	-----	0.82	-----
Dicalcium phosphate		0.12	0.09	-----	0.06
Limestone		0.05	0.06	-----	0.07
Salt		0.12	0.12	0.12	0.12
Silage[b]		29.92	30.05	29.98	30.44
Total (air-dry basis)		23.0	23.0	23.0	23.2
Air dry feed/lb gain		10.2	8.9	8.9	9.2
Feed cost/100 lb gain, dollars[c]		17.36	16.20	18.16	17.42

[a]Data of 146-day feedlot trial (June 17, 1970 to Nov. 10, 1970).
[b]Dry matter (45.5%); crude protein (4.3%).
[c]Based on corn at $1.72 per bu, soybean meal at $102.50 per ton, fishmeal at $255 per ton, linseed meal at $120 per ton, dicalcium phosphate at $106 per ton, limestone at $31 per ton, salt at $43 per ton and silage at $10 per ton.

PREFORMED PROTEIN SOURCE IN ALL-CONCENTRATE AND MINIMUM ROUGHAGE RATIONS FOR FINISHING STEERS

R. L. Ludwick, J. A. Boling and N. W. Bradley

Performance and feed efficiency of steers fed all-concentrate diets are generally lower than when these same rations are fed in combination with roughages. However, the minimum quantity of roughage that produces the maximum response is not known. When roughages, such as hay, are added to concentrate rations the effects may be the result of the roughage or of the addition of minerals and unidentified growth factors to the rumen. To study the roughage effects and minimize the addition of nutrients to the rumen, straw was used as the source of roughage in this study. The objective of this study was to determine the effect of roughage level and source of protein supplementation of all-concentrate rations on the performance of finishing steers.

Ninety-six steers weighing an average of 693 lb were allotted at random to 12 lots of 8 steers each. Each lot of steers was randomly assigned in a 2 x 3 factorial arrangement to three dietary roughage levels and two sources of supplemental protein. The dietary roughage levels were 0, 0.25 and 1.0 lb of straw per head daily. The supplemental protein sources were soybean meal in one ration and soybean meal and fishmeal in the second ration (equal quantities of protein were supplied by the soybean meal and fishmeal). The rations were formulated to contain 12.5% crude protein. The ingredient composition and chemical analysis of the rations are shown in Table 1.

Table 1.—Ingredient and Chemical Composition of Experimental Rations

Item	Protein Supplement	
	Soybean Meal	Soybean Meal and Fishmeal
Ingredient, %		
Corn	86.91	89.14
Soybean meal	10.85	5.15
Fishmeal	-----	3.67
Salt	0.50	0.50
Limestone	0.90	0.70
Molasses	0.50	0.50
Trace minerals[a]	0.34	0.34
Chemical composition, %		
Dry matter	90.6	90.5
Crude protein	10.3	11.5

[a]Trace mineral supplement was formulated to supply approximately twice the recommended dietary levels of: iron, zinc, manganese, copper, iodine, molybdenum and cobalt.

The steers were full fed the concentrate rations twice daily. Straw was fed once daily between the morning and evening feedings. All steers were individually weighed at 28-day intervals. At slaughter, the rumen epithelium and liver of each steer were inspected for the presence of abscesses.

The performance of the steers fed the various levels of roughage and protein supplements is presented in Table 2. Feeding 0.25 lb of straw per steer daily resulted in a 0.22 lb improvement in average daily gain (ADG) for each of the sources of supplemental protein, compared with ADG of the steers fed only the all concentrate ration. The addition of 1.0 lb of straw per steer daily resulted in a 0.43 and 0.61 lb improvement in ADG for the soybean meal and fishmeal + SBM supplemented rations, respectively, as compared with the all-concentrate ration. Feed efficiency and concentrate intake tended to be improved in both rations by the addition of straw. The carcasses of the steers fed straw tended to have a higher grade and marbling score.

Table 2.—Effect of Source of Supplemental Protein and Level of Roughage on Performance of Steers

Protein supplement	Soybean Meal			Fishmeal and Soybean Meal		
Straw per steer daily, lb	0	0.25	1.0	0	0.25	1.0
Number steers	16	16	16	16	16	16
Average weight data, lb						
Initial weight	695	690	688	692	695	696
Final weight	865	885	906	847	874	919
Gain	170	195	218	155	179	223
Daily gain	1.52	1.74	1.95	1.38	1.60	1.99
Average feed data, lb						
Daily concentrate intake	16.8	17.4	18.6	15.3	16.7	18.8
Lb concentrate/lb gain	11.3	10.1	9.5	11.1	10.6	9.5
No. abscessed livers	11	12	10	12	16	9
Carcass grade[1]	11.0	11.6	11.8	11.2	11.7	11.9
Yield grade[2]	3.0	3.0	3.5	2.6	3.1	3.2
Marbling score[3]	2.7	2.9	3.1	2.2	2.9	3.0

[1] 11 = high good; 12 = low choice; 13 = choice; etc.
[2] 2 = good; 3 = average; 4 = fat; etc.
[3] 1 = traces; 2 = slight; 3 = small; 4 = modest; etc.

The performance of the steers with respect to roughage level is presented in Table 3. Average daily gain, feed intake and feed efficiency were improved by the addition of straw. The addition of straw to the ration appeared to have little effect upon the number of liver abscesses but tended to cause a reduction in the amount of rumen abscesses.

Table 3.—Effect of Roughage Level on Performance of Steers

Item	Straw per Steer Daily, lb		
	0	1/4	1
Number steers	32	32	32
Average weight data, lb			
Initial weight	694	692	692
Final weight	856	880	913
Gain	162	188	221
Daily gain	1.45	1.68	1.97
Average feed data, lb			
Daily concentrate intake	16.0	17.0	18.7
Lb concentrate/lb gain	11.1	10.2	9.5
No. abscessed livers	23	28	19
No. abscessed rumens	8	6	5
Carcass grade[1]	11.1	11.7	11.9
Yield grade[2]	2.8	3.0	3.3
Marbling score[3]	2.4	2.9	3.0

[1] 11 = high good; 12 = low choice; 13 = choice; etc.
[2] 2 = good; 3 = average; 4 = fat; etc.
[3] 1 = traces; 2 = slight; 3 = small; 4 = modest; etc.

The performance of the steers with respect to the source of supplemental protein is presented in Table 4. Average daily gain of the steers fed the ration supplemented with soybean meal was slightly greater than gains of those fed the combination of soybean meal and fishmeal. Feed intake was slightly

higher for the steers fed the soybean meal supplemented ration. Other parameters measured were generally not affected by the source of protein supplementation.

Table 4.—Effect of Source of Supplemental Protein on Performance of Steers

Item	Supplemental Protein	
	Soybean Meal	Fishmeal and Soybean Meal
Number steers	48	48
Average weight data, lb		
Initial weight	691	694
Final weight	885	880
Gain	194	186
Daily gain	1.73	1.66
Average feed data, lb		
Daily concentrate intake	17.5	16.9
Lb concentrate/lb gain	10.1	10.2
No. abscessed livers	33	37
No. abscessed rumens	11	8
Carcass grade[1]	11.5	11.6
Yield grade[2]	3.2	3.0
Marbling score[3]	2.9	2.7

[1] 11 = high good; 12 = low choice; 13 = choice; etc.
[2] 2 = good; 3 = average; 4 = fat; etc.
[3] 1 = traces; 2 = slight; 3 = small; 4 = modest; etc.

SUPPLEMENTAL NITROGEN SOURCES FOR GROWING STEER CALVES

J. C. Willard, J. A. Boling and N. W. Bradley

This experiment was designed to study the effect of different protein sources and levels for growing steer calves.

One hundred forty-three Angus steers averaging 396 lb were randomly allotted to six treatment groups and fed in lots of 12 animals. The 126-day experiment was conducted from November to March. The treatment groups were: (1) corn silage free choice (FC); (2) corn silage FC plus 1 lb soybean meal (44% CP) per steer per day; (3) corn silage FC plus 1½ lb SBM per steer per day; (4) corn silage FC plus approximately 3 lb alfalfa hay per steer per day; (5) corn silage FC plus 1 lb corn-urea mixture (Urea 281) per steer per day; and (6) alfalfa hay FC. The corn-urea mixture was calculated to be isonitrogenous with 1 lb 44% SBM (Treatment 2). The alfalfa-supplemented treatment (4) was adjusted to be isonitrogenous with 1 lb 44% SBM based on periodic analysis of the hay for crude protein.

Feedlot performance and daily intake levels for the steers receiving different rations are shown in Table 1. Steers fed no supplemental nitrogen with corn silage gained significantly less ($P < .05$) than those receiving SBM, urea or alfalfa hay as supplements. Steers fed SBM to supplement the corn silage showed the largest gains ($P < .05$), compared with those fed supplemental urea and alfalfa hay. There was no significant difference between levels of SBM fed and rate of gain. Steers fed urea or alfalfa hay as supplementary nitrogen sources showed significant differences ($P < .05$) from those on the other four rations. The urea and alfalfa supplemented groups of steers showed greater ($P < .05$) gaines than the two groups receiving nonsupplemented rations (corn silage or alfalfa hay alone), but gained less than those getting the SBM-supplemented rations.

Table 1.—Feedlot Performance and Daily Feed Intake of Steer Calves

Treatment	(1) Corn Silage	(2) C.S. + 1 lb SBM	(3) C.S. + 1½ lb SBM	(4) C.S. + 3 lb Alfa.	(5) C.S. + Urea	(6) Alfalfa Hay
No. steers	24	24	24	24	24	23
Initial weight, lb	402	397	390	394	402	392
Total gain, lb/steer	67	175	188	123	123	90
Avg. daily gain, lb	.53[a]	1.39[b]	1.50[b]	.97[c]	.97[c]	.72[a]
Daily Ration (lb)						
Corn silage[d]	23.97	27.00	32.72	21.64	24.87	----
Soybean meal (44%)	----	1.00	1.50	----	----	----
Urea mixture[e]	----	----	----	----	1.00	----
Alfalfa hay[f]	----	----	----	3.17	----	12.73

a, b, c Means on the same line bearing different superscript letters differ significantly (P .05).
d Corn silage averaged 40.3% dry matter and 2.96% crude protein.
e The urea mixture contained 0.13 lb urea 281 and 0, 87 lb ground shelled corn.
f Alfalfa hay averaged 13.88% crude protein on an as fed basis.

COMPARATIVE EFFICACY OF THE HIGH CIS AND HIGH TRANS ISOMERS OF DIETHYLSTILBESTROL FOR STEERS

N. W. Bradley, J. A. Boling and R. L. Ludwick

Diethylstilbestrol (DES) has been used for a number of years to improve weight gain and feed efficiency of growing and finishing steers. Research at various agricultural experiment stations has shown that weight gains are generally improved about 15% and feed efficiency improved about 12% through DES feeding. Diethylstilbestrol may exist in two stereochemical configurations, cis or trans. Under normal conditions equilibrium in DES is approximately 70% trans and 30% cis. However, by increasing or decreasing the trans or cis isomer content of DES, its biological activity is altered depending on the trans to cis ratio present. The present study was undertaken to compare the effects of feeding high cis-DES or high trans-DES to finishing steers on feedlot performance and carcass characteristics.

Ninety-six Angus steers weighing an average of 656 lb were fed in a 140-day growth trial to study the comparative efficacy of the cis and trans isomers of diethylstilbestrol. The steers were randomly allotted to no DES, 10 mg high cis DES and 10 mg high trans-DES per steer daily. The steers were fed in lots of eight, with each treatment replicated four times. The composition of the experimental ration is presented in Table 1.

Table 1.—Composition of Rations Fed to Steers

Item	Treatment		
	No DES	High cis-DES	High trans-DES
Daily intake per steer			
Corn silage	Ad libitum	Ad libitum	Ad libitum
Shelled corn, lb	10.0	10.0	10.0
Supplement, lb	1.5	1.5	1.5
Ingredient composition of supplement, %			
Soybean meal	99.9	99.6	99.6
Vitamin A[a]	0.1	0.1	0.1
DES premix[b]	----	0.3	0.3

[a] Provided 20,000 IU vitamin A per steer per day.
[b] Premix contains 2.0 g of DES per lb.

The average daily gain was significantly ($P < .05$) higher for the steers fed trans-DES than for the steers fed no DES or cis-DES (Table 2). The total weight gain of the steers fed trans-DES for the 140-day feeding trial was 12.1% higher than the weight gain for the control steers and 8.1% higher than the weight gain for the steers fed cis-DES.

Table 2.—Effects of Feeding Cis- or Trans- Stilbestrol on Performance and Carcass Characteristics of Steers

Item	Control	High cis-DES	High trans-DES
Number of steers	30	32	32
Average weight data, lb			
Initial weight	655	658	656
Final weight	928	941	962
Gain	273	283	306
Average daily gain	1.95[a]	2.02[a]	2.19[b]
Average feed data, lb			
Corn silage, as fed	24.4	23.8	24.6
Shelled corn	10.0	10.0	10.0
Supplement	1.5	1.5	1.5
Total intake (air dry basis)	20.7	20.5	20.8
Feed/gain	10.6[a]	10.1[b]	9.6[b]
Carcass data			
USDA grade[c]	13.4	13.5	13.4
Marbling score[d]	3.0	3.3	3.5
Cutability[e]	2.4	2.3	2.4
Ribeye area, sq in	10.9	11.4	11.8
Ribeye area, sq in/100 lb carcass weight	2.0	2.0	2.0
Fat thickness, in[f]	0.45	0.40	0.42

[a, b] Means on the same line bearing different superscript letters differ significantly ($P < .05$).
[c] Choice = 13; high choice = 14; etc.
[d] Slight = 2; small = 3; etc.

The feed per gain ratio was significantly lower for the stilbestrol-fed animals. Feed efficiency was improved 10.4% by feeding trans-DES as compared with that of the steers receiving no DES. Although the difference in the average feed intake between the cis- and trans-DES-fed animals was not significant, the steers fed trans-DES consumed 5.2% less feed per lb of gain than the cis-DES-supplemented animals.

Carcass grade, marbling score, cutability, ribeye area and fat thickness were not significantly affected by treatment. However, there was a trend for an increased marbling score for the steers fed both isomers of DES. This increase tended to be slightly greater for the steers fed trans-DES than for those fed cis-DES.

Approximately 2.8 mg of trans-DES was received per steer daily with an intake of 10 mg of high cis-DES, and 9.8 mg of trans-DES was received per steer daily with an intake of 10 mg of high trans-DES. The total weight gain per steer for the 140-day period was increased 10 lb by high cis-DES and 33 lb by high trans-DES, as compared with the weight gain for the steers fed no DES. This resulted in an improvement in gain per mg of trans-DES intake of 3.6 and 3.4 lb for the steers fed high cis and high trans-DES, respectively. This suggests that the growth response to high cis-DES is due to the presence of trans-DES and that the growth response is directly proportional to the trans-DES intake.

CHROMIC OXIDE AND CRUDE PROTEIN EXCRETION IN STEERS AS INFLUENCED BY WATER RESTRICTION

D. L. Cross, J. A. Boling and N. W. Bradley

Chromic oxide is used for indirect determination of nutrient digestibility for steers on pasture, in the feedlot and in metabolism crates. Reduction in water intake has been noticed for steers confined to metabolism crates. The primary objective of this study was to evaluate the validity of the indicator technique when a limited amount of water was offered to steers in metabolism crates.

Twelve yearling Angus steers averaging 250 kg were assigned to two periods and two treatments in a factorial experiment. Within this arrangement, day of collection and time of day were analyzed as split plot treatments. Each steer received 4 kg of a ground ear corn-urea ration and water-free choice or 60% of the amount consumed free choice daily. The experiment consisted of two periods with six different steers in each period. During each period, fecal grab samples were taken at 2-hr intervals for 48 consecutive hours to establish the diurnal excretion patterns of chromic oxide and crude protein. A 7-day total collection of feces was taken during each period.

Percent recovery of chromic oxide for steers receiving free choice and restricted water treatments was 103.1% and 102.3%, respectively. When free choice water was offered, there was a significant ($P<.01$) correlation ($r=0.25$) between the diurnal excretion patterns of chromic oxide and crude protein. Restricting water to 60% of free choice resulted in a significant ($P<.01$) correlation ($r=0.22$) between the diurnal excretion patterns of chromic oxide and crude protein.

Apparent digestion of crude protein and dry matter was estimated during a 7-day period by the total collection and indicator methods. There was no significant ($P<.05$) difference in apparent digestion of crude protein for treatment or method. There was also no significant ($P<.05$) difference in dry matter digestion for treatment; however, apparent digestion of dry matter differed significantly ($P<.05$) owing to the method.

Chromic oxide concentration was significantly ($P<.05$) increased in fecal dry matter when water was restricted. There was no significant effect due to period, day or time of day on the fecal dry matter concentration or chromic oxide and crude protein concentration in fecal dry matter. Excretion of both nutrients and chromic oxide differed significantly among the steers ($P<.01$).

The reduction in water intake imposed upon these steers in metabolism creates apparently did not affect the pattern of excretion of chromic oxide or the validity of the indicator procedure for estimation of nutrient digestibility.

PLACENTAL AND MAMMARY TRANSFER OF VITAMIN A IN BEEF COWS

R. F. Branstetter, G. E. Mitchell, Jr., R. E. Tucker,
J. A. Boling and N. W. Bradley

The newborn calf is often subjected to severe stresses during the first few days after birth. It is important for the cow to impart adequate amounts of vitamin A to the calf through placental and mammary transfer for optimum resistance to the adverse conditions often prevalent during the calving season. The transfer or radio active vitamin A was studied during gestation and lactation in mature Angus beef cows.

Each cow was infused intravenously with 1.14 mc of tritium-labeled vitamin A acetate in a 20% tween solution to establish liver stores of the labeled vitamin. The cows were bred and supplemental vitamin A was included in an 87% hay, 13% grain ration to maintain liver stores of vitamin A. Liver biopsies were made at 21-day intervals to monitor the liver stores and specific activity of vitamin A in the cows. The calves were sacrificed at birth, before they were allowed to nurse, for the determination of vitamin A and the specific activity of the blood, liver, kidneys and adrenals. Foster calves were placed on the cows to maintain lactation, and samples of colostrum and milk were analyzed to estimate the mammary secretion of vitamin A.

The data in Table 1 indicate that about 48% of the vitamin A in the liver of the calves came from the liver stores of the cow. The amount of vitamin A per gram of liver was low but typical of the newborn calf and demonstrates the need for additional transfer of vitamin A through the milk.

Table 1.—Transfer of Radioactive Vitamin A from Liver Stores of the Cow to the Calf

Cow No.	Cow Liver Specific Activity[1]	Calf Liver Specific Activity[1]	Calf Liver ug of A/g	% From Cow Liver
1	44.2	15.1	5.8	34.1
2	35.2	17.1	8.7	48.5
3	29.8	10.6	3.2	35.5
4	98.8	24.4	7.8	24.7
5	45.8	33.8	16.3	73.7
6	17.8	13.1	2.0	73.6
Average	45.2	19.0	7.3	48.4

[1]DPM per ug of vitamin A.

Specific activity and concentration of the vitamin A in colostrum and milk are shown in Table 2. Plasma from the cows had a lower specific activity (not shown) than the milk and suggests that the mammary tissue has a preference for vitamin A from liver storage over that from dietary sources. Vitamin A and radioactivity were detected in the kidneys but not in the adrenals of the calves.

Table 2.—Transfer of Radioactive Vitamin A from Liver Storage of the Cow to the Colostrum and Milk

Cow No.	Cow Liver Specific Activity[1, 2]	Colostrum Specific Activity	% From Liver	12-Wk. Ave. Liver Specific Activity[2, 3]	12-Wk. Avg. Milk Specific Activity[2, 3]	% From Liver
1	44.2	16.4	37.1	-		
2	35.2	10.8	30.6	52.9	17.2	32.5
3	29.8	11.9	39.9	37.8	17.2	45.5
4	98.8	22.3	22.5	37.8	28.4	78.1
5	45.8	11.6	25.3	37.5	22.1	58.9
6	17.8	24.6	138.2	36.6	23.4	63.9
Average	45.2	16.3	42.3	40.7	21.6	55.2

[1]From biopsy at parturition.
[3]From liver biopsy and milk samples at 21-day intervals.
[2]DPM per ug of vitamin A.

RUMINAL DESTRUCTION OF VITAMIN E ADMINISTERED WITH ETHOXYQUIN OR SODIUM NITRATE

R. E. Tucker, G. E. Mitchell, Jr., W. N. Cannon and N. E. Alderson

Previously observed ruminal disappearance of vitamin E has led to research efforts to explain and control this loss. Since vitamin E, alpha tocopherol, can function as an antioxidant in preserving the quality of fat-soluble feed ingredients, the role of oxidative mechanisms in the ruminal destruction of vitamin E was investigated.

An antioxidant, ethoxyquin, and an oxidizing agent, sodium nitrate, were administered with vitamin E to steers, and recoveries of vitamin E estimated by indicator techniques were compared with control values.

In the first trial five steers fitted with abomasal cannulas were fed 7.2 kg of a 60% corn, 30.8% hay and 2.4% soybean meal ration and received 4.2 g ethoxyquin, 4190 IU of vitamin E and 20 g chromic

oxide at weekly intervals. Abomasal fluid was collected just prior to the administration of vitamin E to establish the concentration of dietary vitamin E passing through the rumen. Another sample was taken 24 hr later to estimate the supplemental vitamin E reaching the abomasum. Each animal was observed through three treatments and three control periods. In the second trial, a similar sampling schedule was followed, with the treatment consisting of 70 g per day of sodium nitrate mixed in the ration with the same weekly administrations of vitamin E and chromic oxide.

Percentage recovery of the supplemental vitamin E is shown in Table 1 for each of the treatments. There were no measurable effects on the recovery of vitamin E due to the antioxidant. The extent of pre-intestinal destruction was comparable to previously obtained values for steers fed a similar ration. In the second trial, sodium nitrate tended to reduce intake, but the recovery of vitamin E was not different from the control values. However, all recoveries in this trial were lower than trial 1 for reasons not yet resolved. These data suggest that the apparent losses of vitamin E were not due to in vivo oxidative mechanisms.

Table 1.—Abomasal Recovery of Vitamin E Administered with Ethoxyquin or Sodium Nitrate to Steers (Percent)[1]

	Trial I		Trial II	
Animal No.	Ethoxyquin[2]	Control[3]	Sodium Nitrate[4]	Control[3]
1	70.4	62.1	24.2	35.8
2	68.4	82.8	37.2	44.1
3	73.1	78.0	40.7	27.6
4	83.8	65.8	-	39.2
5	82.3	77.4	40.8	46.0
Mean	75.6	73.2	35.7	38.5
Standard Deviation	7.0	8.8	11.7	7.3

[1]Each value represents three observations in trial I; in trial II some observations were incomplete.
[2]Steers received 4.2 g ethoxyquin, 4190 IU vitamin E and 20 g chromic oxide by bolus.
[3]Control steers received 4190 IU vitamin E and 20 g chromic oxide.
[4]Steers received 70 g sodium nitrate per day mixed in the ration with vitamin E and indicator as above.

PRE-INTESTINAL DISAPPEARANCE OF VITAMIN D_2 IN RUMINANTS

Aminuddin Parakkasi, G. E. Mitchell, Jr., C. O. Little,
R. E. Tucker and G. T. Schelling

The pre-intestinal disappearance of vitamin A and E has been demonstrated in cattle and sheep. It is possible that similar disappearance may exist with respect to vitamin D. The relatively recent development of gas liquid chromatographic procedures for vitamin D analysis makes it now possible to conduct some vitamin D studies which were not previously feasible. The studies reported here were conducted to evaluate quantitatively the apparent destruction of vitamin D_2 in the digestive tract of the ruminant.

In vitro incubations were conducted to evaluate the effect of rumen fluid or abomasal fluid on vitamin D_2 stability. Rumen samples were collected from three rumen-fistulated steers, filtered through cheesecloth and diluted with a glucose-urea-buffer. Each in vitro incubation tube contained 30 ml of diluted rumen fluid, 22.5 mg of cellulose and 120,000 IU of vitamin D_2. One set of tubes was analyzed immediately, one set was incubated at 39°C for 24 hr and the third set was incubated at 10°C for 24 hr. Samples of abomasal contents were collected from 3 abomasally fistulated steers and filtered through cheesecloth. Thirty ml of abomasal fluid was incubated with 120,000 IU of vitamin D_2 at 39°C for 24 hr. Vitamin D_2 was also incubated in distilled water in a manner identical to that of the abomasal fluid incubation.

An in vivo study was conducted using seven abomasally fistulated wethers. The lambs were group fed alfalfa hay ad libitum and 454 g of concentrate mix per head twice daily for 6 weeks prior to treatment. The treatment consisted of intraruminal administration of 25 million IU of vitamin D_2, 5 g chromic oxide and 5 g polyethylene glycol in gelatin capsules. Abomasal samples were collected prior to and 24 hr after the treatment administration. Losses were estimated from changes in vitamin D: indicator ratios.

The results of the in vitro incubations are summarized in Table 1. The recoveries of vitamin D_2 from the water, zero time rumen fluid and the 10° C rumen fluid incubations were all quite similar. The 74.6% recovery from the 39° C rumen fluid incubation strongly suggests destruction of the vitamin D_2. Failure to observe destruction at 10° C suggests that active microbial metabolism is involved in the destructive process. Recovery of only 87.9% of the vitamin incubated in abomasal fluid indicates some destruction of vitamin D2 but considerably less than that observed in rumen fluid.

Table 1.—Recovery of Vitamin D_2 After Various In Vitro Incubations, %

	Water	Rumen Fluid			Abomasal Fluid
Temperature, °C	39	-	10	39	39
Time, hr	24	0	24	24	24
Steer A	100.5	94.0	101.6	73.0	90.5
B	95.0	89.4	98.0	72.0	86.8
C	96.0	100.3	88.0	78.8	86.5
Average	97.2	94.4	95.9	74.6	87.9

The extremely high levels of vitamin D_2 used in the lamb study in order to facilitate adequate quantitation resulted in some toxicity. Stiffness was noted and one lamb died 10 days after treatment. The recovery of vitamin D_2 is given in Table 2. Although somewhat variable, the results do indicate the disappearance of 16.9% of the vitamin D_2 dosage. The recovery values were calculated from the change in chromic oxide to vitamin D_2 ratio. Polyethylene glycol ratios were not used since vitamin D_2 was not detectable in the particulate-free portion of the abomasal content samples.

Table 2.—Recovery of Vitamin D_2 in the Abomasal Contents of Lambs 24 Hours After Treatment

Lamb No.	Percent Recovery
1	93.8
13	96.2
14	80.1
15	78.8
18	79.4
20	92.2
22	61.2
Average	83.1

In summary, significant amounts of administered vitamin D_2 failed to reach the small intestine of wethers. In vitro studies indicate that there is probably significant destruction resulting from microbial metabolism in the rumen and that some additional destruction may occur in the abomasum.

FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS FED TAPAZOLE

C. L. Fields, J. A. Boling, R. E. Tucker, N. W. Bradley,
R. L. Ludwick and G. E. Mitchell, Jr.

Hypothyroidism has traditionally been associated with obesity. Inhibition of thyroid function with Tapazole has been reported to increase weight gains and improve feed efficiency in beef cattle, particularly during the first 60 days of administration. Although increased feed efficiency is, from a biochemical standpoint, more consistent with the deposition of muscle than fat, little information is available concerning the effect of Tapazole on protein and fat deposition in steers. The objectives of this study were:

(1) to confirm previous reports of increased weight gains and feed efficiency of steers fed Tapazole, and

(2) to determine the influence of Tapazole on the deposition of muscle and fat in the carcass.

Twenty crossbred Charolais-Hereford steers averaging 770 lb were individually fed a basal ration containing 89% ground ear corn, 9.4% soybean meal (44%), 0.6% ground limestone and 1.0% salt. Vitamin A was added at a level of 4 million IU per ton of ration. In addition, each steer received a 24-mg implant of stilbestrol and an intramuscular injection of 1.0 million IU of vitamin A, 0.2 million IU of vitamin D, and 100 IU of vitamin E. After a 30-day preliminary period, shrunk weights were obtained and the steers were randomly alloted into two groups and individually fed 20 lb of either the basal ration or the basal ration plus Tapazole (80 g of Tapazole per ton of ration) throughout the 112-day experiment. All steers were weighed and feed intakes recorded at 14-day intervals. At the end of the 112-day experiment all animals were slaughtered and carcass data obtained. A unilateral section of the 9th through 12th rib was separated into rib eye muscle, trim and bone. Water, nitrogen and fat were determined on rib eye muscle and trim.

Administration of Tapazole resulted in increased average daily gain, feed efficiency, rib eye weight, rib eye area, rib eye water, conformation grade and quality grade, and a decrease in bone weight as presented in Tables 1 and 2.

Table 1.—Performance and Carcass Data

Item	Control[a]	Tapazole[a]
Initial body wt, lb	782.5	776.4
Average daily gain, lb	1.72	2.19[d]
Lb feed/lb gain	11.49	8.47[e]
Dressing, %	59.7	59.7
Carcass shrink, %	2.02	2.04
Rib eye area, sq in	11.8	13.0[d]
Marbling score[b]	4.1	3.6[e]
Conformation grade[c]	12.2	13.7[e]
Maturity score[f]	14.3	14.3
Fat over rib eye, in	0.15	0.21
Cutability, %	52.6	52.7
Kidney, pelvic and heart fat, %	2.65	3.10
Quality grade	10.5	9.6[d]

[a] Mean of 10 observations.
[b] Scale = 1-10, in order of increased degree of marbling.
[c] Scale = 3-17, in order of increased desirability.
[d] $P < .05$.
[e] $P < .01$.
[f] Scale = 1-15, in order of decreasing maturity.

Table 2.—Chemical Composition of the Ninth Through Twelfth Rib

	Control[a]	Tapazole[a]
Rib eye muscle		
Weight, g	1,484	1,590[c]
% water	72.9	74.1[c]
% nitrogen	3.26	3.16
% fat	3.79	2.92
Trim		
Weight, g	2,926	3,146
% water	45.4	46.6
% nitrogen	1.92	1.86
% fat	39.9	39.7
Bone weight, g	1,023	928[d]
Color score[b]	4.7	5.3
pH of rib eye muscle	5.85	5.64

[a]Mean of 10 observations.
[b]Scale = 1-7; 3=dark red, 6=cherry red.
[c]P .05.
[d]P .01.

PATTERN OF DIGESTA PASSAGE AND RUMINORETICULAR MOTILITY IN SHEEP FED HAY AD LIBITUM

N. E. Alderson, G. E. Mitchell, Jr. and C. O. Little

The rate of flow of digesta from the rumen influences not only food intake but also the digestibility of the diet. Previous observations of rate of passage have been indirect owing to the inability to collect digesta flowing through the reticulo-omasal orifice. Changes in rate of flow have been shown after feeding as have changes in ruminal motility. In the experiment reported here, omasal fistulas were used for the collection of digesta. The experiments were conducted to establish patterns of dry matter passage, fluid flow and ruminoreticular motility in wethers fed alfalfa hay processed to give two different particle sizes.

In the first experiment, four wethers fitted with ruminal and omasal fistulas were maintained in metabolism crates and fed at 12-hour intervals alfalfa hay of two different particle sizes ad libitum in a switch back design. Chromic oxide and polyethylene glycol were administered as indicators, with omasal samples being taken at various intervals after feeding over a 7-day collection period. Samples were composited and separated into sediment and supernatant. Dry matter passage and fluid flow were estimated following analysis of sediment dry matter and chromic oxide and supernatant polyethylene glycol.

In the second experiment, the same four wethers were used in a switch back design using the same hays and procedures as in the first experiment except that no chromic oxide was given. Ruminal motility was measured using a toy baloon inserted into the rumen with a water manometer and a tambour attached to a writing arm for continuous recording. Two 24-hr recordings were obtained from each animal on each of the two hays. Primary contractions were counted at 10-min intervals after feeding and average amplitude per primary contraction and number of primary contractions per 10 min determined.

Mean rates of dry matter passage and fluid flow are shown in Table 1. Differences in either observation were not significantly different, indicating that differences in particle size of the two hays were not great enough to exhibit a difference in passage. While there were no significant differences in mean rates, there were patterns of change after feeding. Dry matter passage increased quadratically between the 12-hr feeding intervals. There was a linear decrease in dry matter passage in the first

hour after feeding which was followed by a linear increase during the ensuing 10 hours. Dry matter passage rate was lowest one hour after feeding and reached a peak approximately 1 hr before feeding. Fluid flow decreased linearly over the 12-hr period between feedings. Flow rate increased after feeding and decreased after 45 min, giving a cubic response in the first hour after feeding.

Table 1.—Mean Rates of Dry Matter Passage and Fluid Flow From the Ruminoreticulum of Wethers Fed Coarse and Medium Alfalfa Hay Ad Libitum

	Hay	
	Coarse	Medium
Dry matter (g/hr)	16.3 ± 1.8[1]	14.6 ± 1.2[1]
Fluid (ml/hr)	334.1 ± 60.8	324.2 ± 64.9

[1]Standard error.

The overall correlation between dry matter passage and fluid flow was 0.18, indicating a very small relationship between the two observations. It would appear that the large exchange of water in the rumen has little effect on dry matter passage and that fluid flow and dry matter passage are therefore independent observations.

Results of experiment 2 are shown in Table 2. The higher average contraction rate ($P < .01$) for wethers consuming the coarse hay agrees with reports where long hay was compared with ground hay. Contraction rate reached a peak 20 to 30 min after feeding, decreased and then began to increase shortly before feeding. Contraction amplitude reached a peak approximately 2 hr after feeding and then decreased until around 2-hr pre-feeding. There seemed to be an adverse relationship between amplitude and contraction rate around feeding time. The low correlation of 0.21 between contraction rate and amplitude appeared to result from the inverse relationship being offset by the seemingly positive relationship during the remainder of the 12-hr feeding interval.

The results of the first experiment indicate the value of a soluble marker in estimating digestibility in the ruminoreticulum. Since the soluble phase apparently passes much faster and is independent of the solid phase, an insoluble indicator would allow soluble digesta to pass essentially undetected. Combined with a soluble and insoluble marker, the omasal fistula can provide a means of estimating more directly the extent of digestion in the ruminoreticulum.

Table 2.—Mean Ruminoreticular Contraction and Amplitude in Wethers Fed Coarse and Medium Alfalfa Hay Ad Libitum

	Hay	
	Coarse	Medium
Contractions[1]	12.8 ± 0.3[3]	11.9 ± 0.1[3]
Amplitude[2]	129.5 ± 8.3	162.3 ± 13.8

[1]Contraction/10 min.
[2]mm water.
[3]Standard error.

DIGESTIBILITY AND PASSAGE RATE OF ALFALFA HAY IN WETHERS TREATED WITH HISTAMINE AND FORMIC ACID

N. E. Alderson, G. E. Mitchell, Jr. and R. E. Tucker

Previous work has shown that ruminal contraction and dry matter passage increase as feeding time approaches. Histamine and formic acid have been associated with depressed ruminal motility in ruminants overfed soluble carbohydrates. These experiments were conducted to observe the effects of histamine and formic acid on ruminal motility, passage rate and dry matter digestibility in sheep fed alfalfa hay.

Four wethers with ruminal and omasal cannulas were fed 400 g ground alfalfa hay with a polyethylene glycol marker twice daily in metabolism crates. One hour before feeding, when motility was observed to be greatest, a solution containing 1.0 to 5.0 ml formic acid and 50 to 500 mg histamine was infused into the omasum. Actual concentration of the solution was adjusted to administer an effective dosage, whereas control animals received only water. Ruminal contraction rate and amplitude were determined with a pressure transducer and recorder during three separate intervals of the 12-hr period after feeding.

In a second experiment, the digestibility of ground alfalfa hay was determined when depression of rumen motility was attempted by the previous treatment.

The data in Table 1 indicate that the ruminal contraction rate was lower for the treated wethers during the 60-min pre-feeding period but approached the contraction rate of the control wethers at 2-hr after feeding and was not different until the next infusion. The amplitude of the ruminal contractions tended to compensate for a decreased contraction rate; however, compensation was not as great immediately following the histamine and formic acid infusion. This indicates that total ruminal motility was decreased for this period, but overall dry matter passage and fluid flow rates were not affected. The apparent depression in motility 1 hour before and 1 hour after feeding in the treated wethers did not result in differences in nutrient digestibility, as shown in Table 2. Since previous overall passage rates were not different, nutrient digestibility differences could not be expected.

Table 1.—Mean Ruminoreticular Contractions, Amplitude and Flow in Wethers Treated with Histamine and Formic Acid

	Contractions per 10 Min	
1 hr before feeding	12.1 ± 0.5	16.2 ± 0.5
1 hr after feeding	15.2 ± 0.5	17.1 ± 0.8
10 hr remaining	13.9 ± 1.1	12.1 ± 0.4
	Amplitude[2], mm H_2O	
1 hr before feeding	53.8 ± 4.6	65.9 ± 6.1
1 hr after feeding	95.6 ± 9.8	98.7 ± 4.6
10 hr remaining	117.3 ± 8.3	103.3 ± 5.9
	Flow	
Dry matter (g/hr)	14.5 ± 0.6	13.1 ± 0.5
Fluid (ml/hr)	711.0 ± 222.6	513.2 ± 175.0

Table 2.—Ground Alfalfa Hay Digestibility in Wethers Treated with Histamine and Formic Acid

	Treated	Control
Nitrogen	73.8 ± 1.3	75.4 ± 0.7
Dry matter	61.0 ± 2.5	64.4 ± 0.4
Crude fiber	47.6 ± 3.6	48.6 ± 1.6
Ether extract	52.3 ± 3.5	42.6 ± 7.2
Ash	44.2 ± 3.8	48.8 ± 3.0
Cellulose	54.6 ± 3.1	60.3 ± 0.9

^{14}C-LEUCINE INCORPORATION BY LIVER AND MUSCLES OF INSULIN-TREATED SHEEP

J. L. Call, G. E. Mitchell, Jr., R. E. Tucker, H. E. Amos and N. E. Alderson

Previous experiments have shown that insulin treatment has a marked influence on the levels of free amino acids circulating in the blood of sheep. This suggests that insulin might have an important role in regulating protein synthesis. Measuring the incorporation of radioactivity from a labeled amino acid such as ^{14}C-leucine provides a method of quantitating short term changes in protein synthesis.

Six wethers averaging 35 kg were paired according to body weight and placed in digestion crates for a 7-day adjustment period. Each animal was fitted with temporary jugular catheters. Three hr later a blood sample was taken. An equivalent tracer dosage of ^{14}C-leucine was injected into each member of a pair and 2 min later another blood sample was taken followed immediately by an injection of insulin (0.20 U/kg) or saline. Blood samples were taken at 10-min intervals for 60 min. The animals were then sacrificed. Samples from the leg, diaphragm, and liver were obtained for analysis.

Following insulin treatment, radioactivity in the protein of samples of the leg muscle and diaphragm was increased while radioactivity in liver proteins decreased. The activity of lipid extractable materials from muscle was also increased, while there was less activity in these materials in the liver. The results are considered to be consistent with a major effect of insulin on protein synthesis in sheep.

RUMINAL HISTAMINE IN WETHERS WITH ACUTE INDIGESTION

R. D. Long, G. E. Mitchell, Jr. and C. O. Little

In previous experiments it was demonstrated that level of protein in the diet affects the level of histamine found in rumen contents. Since histamine has been associated with the stresses resulting from excess intake of readily fermentable carbohydrates, this experiment was designed to study histamine levels in the rumen following sudden introduction of a large amount of glucose.

Six wethers with rumen fistulas were used in the experiment. Each wether received 450 g of a semi-purified experimental diet directly into the rumen in a water slurry twice daily for 4 days. Three wethers received a protein-free diet containing 65% purified wood cellulose, 33% corn starch and 2% minerals. For the other three wethers, 10% casein was substituted for 10% of the wood cellulose. On the fourth day, 454 g of glucose was administered. Concentration of histamine in rumen contents was determined immediately before and 1, 2, 4, 8 and 10 hr after glucose treatment.

Average histamine concentration for wethers receiving the protein-free diet increased from a pre-treatment value of 0.86 ug per ml to a peak of 1.36 ug per ml 8 hr after treatment. In wethers receiving 10% casein, average histamine concentration increased from 1.11 ug per ml to a high of 4.01 ug per ml 10 hr after treatment. Lactic acid concentrations were higher and pH values slightly lower for wethers receiving casein.

CELLULOSE DIGESTION IN SHEEP FED AN EXTRACT OF ASPERGILLUS ORYZAE

John W. Niver, R. E. Tucker and G. E. Mitchell, Jr.

Investigations with a fermentation extract of the mold, Aspergillus oryzae, have suggested that the product may improve fiber digestion during the transition to grain-hay diets. Preliminary observations of a loss of rumen protozoa when Aspergillus is fed offers a possible mechanism for influencing ration digestibility.

A 28-day metabolism trial was conducted consisting of treatment and control groups of nine lambs each fed for four 7-day periods. The lambs were restrained in metabolism crates and fed increasing levels of a 47% hay, 46% corn and 6% soybean meal basal ration with or without 900 mg/kg of the A. oryzae extract. Total fecal and urinary collections were than taken for the four 7-day periods and analyzed to determine acid detergent fiber digestibility and nitrogen balance. The data in Table 1 do not show a beneficial effect on fiber digestibility nor an increased nitrogen balance during any of the periods for the treated group. Nitrogen balance in both groups tended to be negatively correlated with fiber digestibility. Defaunation of the rumen was not detected during these trials.

Table 1.—Nitrogen Balance and Fiber Digestibility in Lambs Fed an Extract of Aspergillus Oryzae[1]

	Acid Detergent Fiber Digestibility (%)		Nitrogen Balance (g per week)	
	Control[2]	Treated[2]	Control[2]	Treated[2]
Period 1	55.3	53.8	-1.06	6.99
2	53.8	54.0	9.46	9.08
3	53.6	53.5	26.17	26.67
4	47.7	48.7	23.18	25.96
Mean	52.6	52.5	14.43	17.17
Standard Deviation	3.4	2.6	12	11

[1]Treated lambs received 900 mg of the Aspergillus oryzae extract per kg of ration.
[2]Each value represents an average of nine lambs.

ABSORPTION OF AMINO ACIDS IN SHEEP FED ALFALFA

I. D. Hume, D. R. Jacobson and G. E. Mitchell, Jr.

Previous work has clearly demonstrated the potential for variations in amino acid concentrations reaching the abomasum of ruminants. However, differences in the amino acid compositions of various diets are not consistently reflected in concentrations of amino acids in either the abomasal contents or the blood. Since the amount of amino acids absorbed determines the effectiveness of attempts to control the protein nutrition of ruminants as well as other animals, considerable effort has been expended in developing techniques for quantitating this absorption. In this experiment, a technique adapted to ruminants in this laboratory has been used to quantitate amino acid absorption by sheep fed alfalfa hay.

Total daily amounts of individual amino acids absorbed were measured in three mature wethers, each during four 24-hr periods. The animals were fed 60 g dry matter/kgB.W.0.75/day* (990, 756 and 732 g of total dry matter/day) of chopped alfalfa hay (14.9% crude protein) at 2-hr intervals. Net absorption values (absorption minus utilization by the gut wall) were estimated by multiplying the portal blood volume (measured by the Doppler-shift technique) by the differences in portal-carotid concentrations

*60 g dry matter per kilogram of body weight to the 0.75 power per day.

of each amino acid studied. Samples of portal and carotid blood were withdrawn from permanent Vivosil catheters (1.2 mm I.D.) at 8 am, 2 pm, 8 pm and midnight during each 24-hr period of measurement. Each sample was subsampled for hematocrit determinations, and the remainder centrifuged to remove cells, then deproteinized with sulfosalicylic acid. The four plasma samples obtained in each 24-hr period from each site were combined on an equal volume basis, and individual amino acid concentrations determined by automated procedures (Technicon).

Mean portal blood flow was 39.3 $\pm$ 3.40 ml/min/kg bodyweight. Mean net absorption of total amino acids was 48.9 $\pm$ 13.42 g/day (22.2 $\pm$ 8.64 g essential, 26.7 $\pm$ 4.97 g non-essential), approximately 50% of the daily intake. The individual essential amino acids were absorbed in ratios similar to those found in rumen bacterial protein. Of the non-essential amino acids, aspartic and glutamic acids were absorbed to a lesser extent than their proportions in rumen bacterial protein (presumably because of transamination to other amino acids and their conversion to the corresponding amides in the gut wall; absorption of asparagine and glutamine was not measured). On the other hand, proline and alanine were absorbed to a greater extent than their proportions in rumen bacterial protein. Alanine is a likely transamination product.

ABSORPTION OF LEUCINE INFUSED INTO THE ABOMASUM OF SHEEP

I. D. Hume, D. R. Jacobson and G. E. Mitchell, Jr.

Much of the zein protein in corn is known to be resistant to microbial attack in the rumen and to pass into the post-ruminal digestive tract. This zein contains more than twice as much leucine as microbial protein (18.2% vs. 7.3%). Potential antagonism between leucine and another essential amino acid could be detrimental, especially if the affected amino acid was limiting. This experiment was conducted to test for possible effects of large amounts of leucine on the post-ruminal absorption of amino acids.

Two mature wethers were fed 60 g dry matter/kgB.W.0.75/day (756 and 732 g dry matter/day) of chopped alfalfa hay at 2-hr intervals. In addition, L-leucine was continuously infused into the abomasum at the rate of 0, 10 or 30 g/day in 1500 ml water. Total daily amounts of individual amino acids absorbed were measured to examine the possibility of antagonism during absorption between leucine and other amino acids.

Net absorption values were estimated by measuring portal blood flow by the Doppler-shift technique and multiplying the resulting volume by portal-carotid concentration differences. Amino acid absorption was measured over two 24-hr periods in each sheep for each level of leucine infusion after a preliminary infusion period of 2 days. Infusion of leucine increased portal blood flow ($P < 0.05$). Net absorption of leucine was increased only at the highest level of infusion ($P < 0.01$). Infusion of leucine depressed net absorption of lysine ($P < 0.05$). Net absorption of methionine tended to increase ($P < 0.10$) and that of proline to decrease ($P < 0.10$) when leucine was infused. The depression of lysine absorption by leucine is of potential importance, not only because of the high leucine content of zein but also because of its very low lysine content.

BILIARY EXCRETION OF INJECTED VITAMIN A IN SHEEP - EFFECT OF REPLACING COLLECTED BILE

I. D. Hume, G. E. Mitchell, Jr., and R. E. Tucker

Cannulation of the common bile duct has made it possible to quantitate the biliary excretion of labeled vitamin A compounds administered to sheep. This experiment was designed to examine the amounts of injected labeled vitamin A excreted in the bile of sheep both with and without duodenal infusion of unlabeled bile to replace the radioactive bile collected. In previous biliary excretion studies collected bile was not replaced.

Two mature Hampshire ewes were fitted with modified re-entrant cannulae in the common bile duct. One week after surgery the sheep were restrained in metabolism crates and were offered chopped alfalfa hay and water ad libitum. The first trial commenced 2 weeks after surgery. The two ewes were injected via the jugular vein with 30.8 uCi of retinyl acetate-11, 12-^{3}H on four occasions, each 1 week apart. The day prior to each injection each ewe was also fitted with a urinary bladder catheter. Total bile and urine collections were made at timed intervals for 24 hr after each injection, the volume recorded and

the ^{3}H-activity counted in a liquid scintillation counter. On the first and third occasions collected bile was not replaced. On the second and fourth occasions collected bile was replaced by infusing unlabeled bile collected previously into the duodenum throughout the collection period at 36 ml/hr. This rate of infusion is within the normal range of bile flow rates observed in sheep.

When collected bile was not replaced, an average of 22.9% of the activity injected as retinyl acetate-11, 12-^{3}H was recovered in the bile. When unlabeled bile was infused into the duodenum, the recovery of injected ratioactivity in the bile increased to 31.0% ($P<0.001$). At the same time, the average volume of bile produced in 24 hours increased from 406 ml to 1,287 ml ($P<0.01$). Increases in the flow of urine (654 ml without vs 861 ml with bile replacement) and in the recovery of injected radioactivity in the urine (32.9% vs 37.0%) were not significant ($P<.05$). These results indicate that quantitative data on the biliary excretion of vitamin A metabolites are likely to be more meaningful physiologically if unlabeled bile is continuously infused into the duodenum to replace the bile removed during collection.

ENTERO-HEPATIC RECYCLING OF VITAMIN A IN SHEEP

I. D. Hume, G. E. Mitchell, Jr. and R. E. Tucker

Earlier experiments at Kentucky demonstrated the recirculation of biliary metabolites of vitamin A from the small intestine to the liver of sheep. The recirculated metabolites have not been fully identified. However, the recirculation would be of considerable importance if the recirculated metabolites are capable of conversion to an active form of vitamin A. The resulting reuse of vitamin A would reduce the requirement by an amount equivalent to the amount reused. This experiment was designed to examine the possible quantitative importance of the recirculation.

Two mature Hampshire ewes were fitted with modified re-entrant cannulae in the common bile duct. One week after surgery the sheep were restrained in metabolism crates and were offered chopped alfalfa hay and water ad libitum. The day before collection catheters were fitted into the bladder for collection of urine. Fifty ml of bile containing ^{14}C-leucine vitamin A metabolites were infused into the re-entry tube of the common bile duct cannula of the two ewes, each on two occasions 1 week apart. The labeled bile had been collected after jugular injection of retinoic acid-14-^{14}C in a previous experiment. The 50 ml of bile infused in each trial contained 1.35 uCi of ^{14}C-activity, and was infused into the duodenum during a 50-min period. Unlabeled bile was then infused into the duodenum throughout the remainder of the 24-hr collection period, during which total collections of bile and urine were made at timed intervals.

An average of 25.3% of the radioactivity infused into the duodenum was absorbed and excreted in the bile in 24 hr (85.0% of this in the first 12 hrs) and 8.1% in the urine (87.6% in the first 12 hr). These results agree closely with those obtained from rats and indicate that substantial amounts of vitamin A metabolites are recycled from the small intestine to the liver of sheep. It is suggested that this mechanism may be important to the vitamin A economy of the animal, especially during periods of vitamin A deprivation.

DIURNAL VARIATIONS IN AMINO ACID ABSORPTION IN SHEEP

I. D. Hume, D. R. Jacobson, and G. E. Mitchell, Jr.

Total amounts and diurnal patterns of amino acid absorption were studied in two wethers fed fixed amounts of chopped alfalfa hay either once daily or every 2 hr. Net absorption values were the product of portal blood flow (measured by the Doppler-shift technique) and portal-carotid concentration differences. When the wethers were fed once daily, portal blood flow increased approximately 25% to a single maximum 5 to 7 hr after feeding, then declined to the pre-feeding level; but there were two periods of net positive absorption, 0 to 4 hr after feeding, and 6 to 14 hr after feeding. At all other times net absorption was negative, suggesting substantial utilization of absorbed amino acids by the gut wall. This diurnal variation in amino acid absorption is surprising in view of the continuous nature of the flow of digesta through the intestine of ruminants. When fed every 2 hr there was no consistent diurnal pattern in either portal blood flow or amino acid absorption. There was also no significant difference in the total daily amounts of amino acids absorbed on the two feeding regimes.

EVALUATION OF HEAT, FORMALDEHYDE AND TANNIC ACID TREATED SOYBEAN MEAL FOR LAMBS

J. F. Nishimuta, D. G. Ely and J. A. Boling

The utilization of dietary nitrogen by the ruminant is dependent on the interrelated chemical and physical properties of the dietary protein. Soybean meal protein is of high quality but, being also highly soluble in rumen fluid, a large proportion of the nitrogen may be lost from the animal as urinary urea owing to its rapid conversion to ammonia by the rumen microbes.

Heat, formaldehyde, and tannic acid treatments are among the methods implemented by various researchers to decrease the solubility of soybean meal protein. Such treatments should make adequate nitrogen available as rumen ammonia for incorporation into microbial protein and still allow a significant amount of the high quality soybean meal protein to bypass the rumen. Therefore, the protein requirement of the animal as a whole may be more efficiently fulfilled.

This study was implemented to compare the various treatments with regular soybean meal in high-roughage rations in regard to the afore-mentioned objectives.

The experimental rations are shown in Table 1. Heat-treated soybean meal (H-SBM) was prepared by heating solvent-extracted soybean meal for 4 hr at 149 C. The formaldehyde-treated soybean meal (F-SBM) was prepared by the addition of 1% formaldehyde by weight and the tannic acid-treated soybean meal (T-SBM) by the addition of 9% tannic acid by weight. The corn cob fraction of rations were adjusted in the F-SBM and T-SBM rations so that the four rations would be isonitrogenous.

Table 1.—Ingredient Composition of Rations

Ration	SBM	H-SBM	F-SBM	T-SBM
Ingredient, %:				
SBM	17.40	17.40	17.59	19.08
Ground shelled corn	20.00	20.00	20.00	20.00
Ground corn cobs	61.50	61.50	61.31	59.82
Trace mineralized salt	0.50	0.50	0.50	0.50
Dicalcium phosphate	0.60	0.60	0.60	0.60

Sixteen crossbred wether lambs averaging 35.0 kg were randomly allotted to four per treatment for a nitrogen balance trial. The lambs were maintained in metal metabolism stalls. A 7-day feces and urine collection period followed a 14-day ration adjustment period. Daily intake was held constant at 800 g fed in two feedings. Water was available at all times. Total wet feces was weighed, sampled (10% aliquot) and composited daily for analysis. Total daily urine was diluted to a constant volume and a 10 ml aliquot composited for analysis.

Results of the nitrogen balance trial are presented in Table 2. Nitrogen digestibility, percent of intake retained, and percent of digested retained indicate treatment of the SBM decreases microbial degradation to ammonia and subsequent nitrogen loss. However, formaldehyde also decreased soybean meal susceptibility to post-ruminal degradation as indicated by the proportion of fecal nitrogen and the percent of intake retained. This is in conflict with other reports on formaldehyde treatment of soybean meal. It apparently did not affect the post absorptive utilization of the soybean meal nitrogen since the percent of nitrogen digested retained is comparable to that of the heat treated. The effect may be due to either resistance of the F-SBM to enzyme degradation or inactivation of the post-ruminal enzymes by formaldehyde. Tannic acid treatment, however, may have slightly depressed tissue utilization.

Heat and tannic acid treatments improved utilization, whereas formaldehyde treatment depressed the utilization of soybean meal nitrogen as compared with untreated soybean meal.

Table 2.—Nitrogen Digestibility and Balance

Ration	SBM	H-SBM	F-SBM	T-SBM
Total N intake, g	96.92	99.52	87.47	94.28
N intake, g/day	13.84	14.22	12.50	13.47
Fecal N, g/day	3.40	4.27	6.69	4.37
Urine N, g/day	7.57	6.02	3.63	5.93
N digestibility, %	75.44	69.95	46.45	67.55
N retained, g/day	20.14	27.46	15.18	22.18
% of intake retained	20.78	27.60	17.36	23.52
% of digested retained	27.59	39.47	37.09	34.84

UREA AND HEATED SOYBEAN MEAL SUPPLEMENTATION TO LAMB RATIONS

D. G. Ely, W. P. Deweese and H. E. Amos

In general, nitrogen utilization by lambs has been slightly increased by decreasing the solubility, through heating, of a high-quality dietary nitrogen source such as soybean meal. It has been found that some readily available nitrogen source, such as urea, is beneficial to rumen function when an insoluble nitrogen source is fed. This study was initiated to determine the effects of reducing dietary soybean meal solubility and replacing different portions of this meal with a more readily available nitrogen source in rations for young lambs.

Sixty-six crossbred lambs weighing approximately 18 kg were employed in two trials to compare growth of lambs fed rations supplemented with heated soybean meal (HSBM) or urea. Lambs were randomly assigned within sex at 56 days of age to three rations supplemented with either HSBM, one-half HSBM and one-half urea (HSBM-urea) or urea (Table 1).

Table 1.—Composition of Rations (%)

Ration	HSBM[a]	HSBM-Urea	Urea
Ingredients:			
Ground wheat straw	10.00	10.00	10.00
Ground alfalfa hay	10.00	10.00	10.00
Ground shelled corn	60.00	64.90	68.70
Soybean meal (44% C.P.)	10.00	4.35	--
Urea 281	--	0.75	1.30
Cane molasses	8.00	8.00	8.00
Steamed bone meal	1.00	1.00	1.00
Trace mineralized salt	1.00	1.000	1.00

[a]Heated soybean meal.

Rations contained approximately 11.1% crude protein and were offered ad libitum. Urea nitrogen provided 17.5% and 31% of the total ration nitrogen in the HSBM-urea and urea rations, respectively. HSBM was prepared by layering the meal 2.54 cm deep in aluminum trays and heated at 149 C for 4 hr in a forced-air oven. The feeding periods were 96 and 84 days in Trials 1 and 2, respectively. No differences in average daily gain, feed intake or feed efficiency were found in Trial 1 (Table 2). In Trial 2, lambs fed HSBM had greater daily gains (Table 3). However, lambs receiving the urea ration were the most efficient converters of feed to grain. No differences in digestibility of dry matter, nitrogen, ether extract, ash or cellulose were found. Grams of nitrogen retained per day per lamb were 2.1, 1.1 and 1.4 for the HSBM, HSBM-urea and urea rations, respectively.

Table 2.—Performance of Lambs Fed HSBM[a] and Urea (Trial 1)

Ration	HSBM	HSBM-Urea	Urea
Number of lambs	10	10	10
Initial wt, kg	17.3	18.0	16.5
Final wt, kg	38.6	38.8	37.2
Total gain, kg	21.3	20.8	20.7
Average daily gain, kg	0.22	0.22	0.22
Daily feed intake, kg	1.36	1.36	1.37
Feed/gain, kg	6.18	6.18	6.23

[a]Heated soybean meal.

Table 3.—Performance of Lambs Fed HSBM[a] and Urea (Trial 2)

Ration	HSBM	HSBM-Urea	Urea
Number of lambs	12	12	12
Initial wt, kg	18.5	18.5	18.5
Final wt, kg	41.2	39.2	38.3
Total gain, kg	22.7	20.7	19.8
Average daily gain, kg	0.27	0.25	0.24
Daily feed intake, kg	1.56	1.48	1.35
Feed/gain, kg	5.78	5.92	5.63

[a]Heated soybean meal.

These data indicate that replacing one-half of HSBM-nitrogen with urea was not conducive to increasing efficiency of nutrient utilization in the young lamb weaned at 56 days of age. Also, urea can apparently be utilized efficiently and economically when the urea nitrogen provides approximately one-third of the total nitrogen in rations self-fed to lambs weaned at 56 days of age and fed from 18 to 40 kg body weight.

EFFECT OF OPAQUE-2 CORN AND PROTEIN LEVEL ON THE NITROGEN UTILIZATION OF EARLY WEANED LAMBS

S. E. Fry, D. G. Ely, W. P. Deweese and G. L. Cromwell

Opaque-2 (high lysine) corn has received considerable attention by nonruminant researchers because this corn provides more lysine to the absorption sites of the animal than does regular yellow corn. Therefore, performance of pigs and chicks fed opaque-2 corn has been superior to that resulting when regular corn was fed. The lamb is born without a functional rumen and may therefore be considered a nonruminant. If the lamb without a functional rumen is fed opaque-2 corn, performance may be superior to that obtained when regular corn is fed. The objective of this experiment was to compare the growth of young lambs fed opaque-2 or regular yellow corn at two protein levels.

Seventy-two Hampshire-sired crossbred lambs were employed in two trials. All lambs were weaned at an average of 35 days and fed preweaning creep (Table 1) ad libitum for an additional eight days. Lambs were allotted according to age, weight, sex and type birth. Forty-eight of these lambs were allotted into pens of four, and each pen fed ad libitum one of the four rations shown in Table 2. Rations 1 and 2 utilized ground opaque-2 corn and contained 14% and 18% crude protein, respectively. Rations 3 and 4 were composed of ground yellow corn and contained 14% and 18% crude protein, respectively. Soybean meal was used to adjust crude protein content of the rations. Average daily gain (ADG) and feed efficiency were measured for an 80-day period. Although there were no significant

differences ($P < .05$) in ADG, performance tended to be slightly better with ration 2 (opaque-2, 18% crude protein) than with the other rations. Ration 2 also was utilized more efficiently: 4.02 kg of feed/kg gain vs 4.15, 4.13, 4.12 for rations 1, 3 and 4, respectively.

Table 1.—Composition of Pre-weaning Creep Ration

Ingredient	%
Ground shelled corn	32.6
Dehydrated alfalfa meal	20.0
Soybean meal (44% C.P.)	22.0
Dried whey	15.0
Sucrose	2.5
Cane molasses	5.0
Dicalcium phosphate	1.0
Ground limestone	0.5
Trace mineralized salt	0.4
Vitamin premix	1.0

Table 2.—Composition of Rations (%)

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4
Ground Opaque corn	81.58	71.58	--	--
Ground yellow corn	--	--	81.50	71.58
Soybean meal (44% C.P.)	10.00	20.00	10.00	20.00
Cane molasses	5.00	5.00	5.00	5.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Ground limestone	0.50	0.50	0.50	0.50
Trace mineralized salt	.25	.25	.25	.25
Vitamin premix	.67	.67	.67	.67
Aureomycin (to provide 40 g/ton)	1.00	1.00	1.00	1.00

The other 24 lambs were treated similarly except that they were placed in specially designed digestion crates where they could move about freely. No ration differences were found for nitrogen or dry matter digestibility or for nitrogen balance.

Table 3.—Results of Feedlot Trial

Item	Ration 1	Ration 2	Ration 3	Ration 4
No. lambs	12	12	12	12
Avg. initial wt, kg	12.9	12.9	13.6	13.2
Avg. final wt, kg	34.3	36.5	34.5	34.5
Total gain, kg	21.4	23.6	20.9	21.3
Avg. daily gain, kg	0.27	0.30	0.26	0.27
Kg feed/kg gain	4.15	4.02	4.13	4.12

These trials show that lambs can be weaned as young as 35 days with no detrimental effects on either viability or performance. Evidence, to this point, also indicates that there is no advantage in exceeding 15% crude protein in rations of early weaned lambs. Opaque-2 corn when compared with regular yellow corn had little effect on performance.

APPARENT EXCESSES OF AMINO ACIDS IN WHOLE EGG PROTEIN

G. T. Shelling, R. Richardson and G. E. Mitchell, Jr.

Whole egg protein has been accepted as one of the highest quality proteins. The supplementation of whole egg protein with crystalline amino acids has, however, generally failed to produce gain responses in rats. The problem with the classical approach of supplementing with individual amino acids is that if two or more amino acids are equally limiting gain, a gain response will not occur unless all of the equally limiting amino acids are provided. In the evaluation of a high quality protein where several amino acids might be expected to be nearly equally limiting, a large number of treatments is required to provide all possible combinations of the amino acids in question. Therefore, if a limited number of treatments is involved, the chance of not detecting the limiting amino acids is considerable. If a protein having seven limiting amino acids for rats existed, it could conversely be viewed as having an excess of three amino acids. These rat studies were designed to detect excessive amounts of the individual essential amino acids in whole egg protein.

Two 21-day rat gain trials were conducted to evaluate the effect of supplementing a basal diet containing 10.0% whole egg with 10 of 11 amino acids (the essential amino acids plus glutamic acid) at a level of 10.0% of the requirements established by the National Research Council (NRC). The total treatments evaluated included the single elimination of each one of the 11 amino acids. The control diets consisted of a diet containing only 10.0% whole egg and another diet containing 10.0% whole egg plus all 11 amino acids at a level of 10.0% of the NRC requirements.

The basal diets contained 77.0% corn starch, 10.0% whole egg, 5.0% corn oil, 4.0% mineral mix, 3.0% cellulose, and 1.0% vitamin mix. The amino acids were added to the diet at the expense of corn starch. Ten 70-g rats were used per treatment.

The performance of rats in the first experiment is given in Table 1. Those fed the basal diet gained 1.10 g/day while those fed the basal plus the 11 amino acids gained 2.71 g/day. These performances were arbitrarily set at % responses of 0.0 and 100.0, respectively. The rats fed the diet devoid of supplemental leucine (containing 10 of the 11 supplemental amino acids) gained 2.07 g/day and exhibited a 60.2% response over the basal diet. Likewise, the rats fed diets devoid of supplemental isoleucine, threonine and valine gained 2.03, 0.37 and 2.42 g/day and exhibited 57.8, -45.3 and 82.0% responses, respectively. The level of feed consumption and, therefore, the gain per unit feed closely paralleled the gain.

Table 1.—Performance of Rats. Experiment 1.

Treatment	ADG	Response	Feed Consumption	Gain/Feed
	g	%	g/day	
A. Basal	1.10	0.0	9.28	0.118
B. A plus 10 essential acids and Glutamic acid	2.71	100.0	12.18	0.222
C. B minus Leucine	2.07	60.2	11.14	0.186
D. B minus Isoleucine	2.03	57.8	10.84	0.187
E. B minus Threonine	0.37	-45.3	6.92	0.053
F. B minus Valine	2.42	82.0	11.31	0.214

The data in Table 1 indicate that the rats fed diets devoid of supplemental leucine, isoleucine or valine responded in performance (over the basal) although these amino acids were not supplied in the supplement. Therefore, it is probable that the whole egg in the basal diet contained an excessive amount of each of these amino acids. The negative response observed when the diet devoid of supplemental threonine was fed is presumably the result of an amino acid imbalance.

The performance of the rats in the second experiment is given in Table 2. Again, the gain per unit feed data closely parallel the gain data. Inspection of this table reveals that rats fed the diets devoid of supplemental methionine, arginine, phenylalanine, and tryptophan performed better than the

rats fed the basal diet. Therefore, these amino acids appear to be present in whole egg in excessive amounts. It is questionable whether the performances of rats fed the diets devoid of supplemental lysine or histidine are really different than those fed the basal diet. There appears to be a response when the diet devoid of supplemental glutamic acid was fed. A response due to this treatment could result from non-essential nitrogen production from the metabolism of excessive amounts of essential amino acids as well as excessive amounts of non-essential nitrogen in the whole egg.

Table 2.—Performance of Rats. Experiment 2.

Treatment	ADG	Response	Feed Consumption	Gain/Feed
	g	%	g/day	
A. Basal	1.04	0.0	8.76	0.118
B. A plus 10 essential amino acids and Glutamic acid	2.28	100.0	10.38	0.220
C. B minus Methionine	1.93	71.8	9.42	0.205
D. B minus Lysine	1.16	9.7	8.42	0.138
E. B minus Histidine	0.74	-24.2	7.58	0.098
F. B minus Arginine	2.00	77.4	9.79	0.204
G. B minus Phenylalanine	2.13	87.9	9.87	0.215
H. B minus Tryptophon	2.09	84.7	10.14	0.206
I. B minus Glutamic acid	1.42	30.6	9.54	0.149

The results of this study indicate that whole egg contains 7 of the 10 essential amino acids in amounts greater than required for optimum growth of the young rat. The seven amino acids are leucine, isoleucine, valine, methionine, arginine, phenylalanine and tryptophan.

EFFECT OF SOYBEAN MEAL, LYSINE AND METHIONINE SUPPLEMENTATION TO OPAQUE-2 AND NORMAL CORN ON PERFORMANCE OF YOUNG PIGS

C. R. Marroquin, G. L. Cromwell, and V. W. Hays

One hundred-thirty-eight pigs initially averaging 9.9 kg body weight and 45.9 days of age were randomly allotted from weight outcome groups to six treatments to evaluate diets containing opaque-2 corn (0.42% lysine) with 10.0, 12.5, 15.0, 17.5 and 20.0% soybean meal. Each diet was offered ad libitum to 12 replicate pens of 1 or 2 pigs each for a 28-day test period. Pigs were penned in metal cages with expanded metal floors.

A significant ($P < .01$) linear improvement in rate of gain and feed required per unit of gain resulted as level of soybean meal increased from 10 to 20% in the opaque-2 diets (429, 452, 474, 499, 516 g/day; 2.42, 2.30, 2.20, 2.07, 1.97). Pigs fed the normal corn-soybean meal diet gained an average of 496 g/day and required 2.07 kg of feed per kg of gain.

In a second experiment, a 2 x 2 x 2 factorial arrangement of treatments was used to evaluate opaque-2 or normal corn in diets with and without 0.1% added L-lysine and with and without 0.1% DL-methionine. A level of 10.0% dehulled soybean meal was incorporated in all diets. A ninth treatment included normal corn plus 20% soybean meal. Each diet was individually fed to eight pigs initially averaging 31.9 days of age and 8.1 kg for 35 days.

Pigs fed normal corn plus 20% soybean meal gained faster (453 vs 360 g/day) and were more efficient (2.25 vs 2.38) than those fed diets containing 10% soybean meal. Neither lysine nor methionine addition influenced gain or feed/gain responses of pigs fed either of the corn types. Main effects for 0 vs added lysine, 0 vs added methionine and normal vs opaque-2 corn were: gain (g/day), 357 vs 363, 359 vs 361, 337 vs 383; feed/gain, 2.43 vs 2.33, 2.40 vs 2.36, 2.49 vs 2.27. The 2-way and 3-way interactions were small and nonsignificant.

EFFECT OF BLIGHTED CORN ON THE PERFORMANCE OF GROWING-FINISHING PIGS

M. D. Whiteker

An experiment involving 80 Hampshire X Yorkshire crossbred pigs was conducted to study the effects of various levels of blighted corn on growth rate and feed conversion of growing-finishing pigs. The blighted corn had a test weight of 52.5 lb per bushel and assayed 9.6% crude protein. The corn yielded about 60 bu per acre where a yield of 110 bu was expected. The corn showed typical symptoms of blight in the field, and the grains were generally shrivelled with some grains having a dark appearance.

The five ration treatments listed included 0, 25, 50, 75 or 100% of the corn from blighted corn (Table 1). The pigs were randomly allotted to treatment from groups based on weight within sex. Each of the five treatments was imposed on four replicate pens of four pigs each. The average initial weight of the pigs was 61.7 lb, and the average final weight was 143.6 lb. The pigs were on test for 7 weeks. A 14% corn-soybean meal diet (based on a protein content of 8.8% in the normal corn) fortified with vitamins and minerals was fed for the duration of the experiment. The basal diet contained 84% corn. No adjustment was made for the higher protein level in the blighted corn.

The results of the experiment are summarized in Table 1. Blighted corn appeared to have little if any detrimental effects on the performance of growing-finishing pigs. The differences observed were not statistically significant ($P < .05$).

Table 1.—Effect of Blighted Corn on the Performance of Growing-Finishing Pigs

	Percent of Ration				
Normal corn	100	75	50	25	0
Blighted corn	0	25	50	75	100
Av initial wt, lb	62.7	63.2	62.6	62.8	62.2
Av final wt, lb	144.4	147.6	143.1	142.5	140.5
Av daily gain, lb	1.67	1.72	1.64	1.63	1.60
Feed/gain	3.09	3.08	3.12	3.14	3.09

General Recommendations for Feeding Blighted Corn:

1. Blighted corn can be fed to growing-finishing pigs.
2. Use caution in feeding blighted corn to sows. Test-feed the corn to some open, sexually mature gilts and if any reactions (continued swelling of the vulva, etc.) are observed, don't feed the corn to gestating sows.
3. Other invading fungi or molds could have detrimental effects not observed in this particular trial.

EFFECT OF DIETARY PROTEIN AND FAT LEVELS ON CARCASS MEASUREMENTS AND EATING QUALITY OF PORK

J. E. Drews, R. L. Best, G. L. Cromwell, V. W. Hays, J. D. Kemp and W. G. Moody

Diets containing 10 or 20% protein with 0 or 10% added fat were fed to three pens of two pigs each from an average weight of 10 to 46 kg. At 46 kg the protein level was switched for half the pigs, resulting in the following eight dietary treatments: (10-10% protein, 0% fat; 10-10% protein, 10% fat; 10-20% protein, 0% fat; 10-20% protein, 10% fat; 20-20% protein, 0% fat; 20-20% protein, 10% fat; 20-10% protein, 0% fat; and 20-10% protein, 10% fat. Fat was replaced and protein levels were adjusted with a mixture of starch and dextrose so that all diets contained a constant ratio of corn and soybean meal.

Pigs were slaughtered at 91 kg and standard meat laboratory and taste panel measurements were collected.

Backfat (cm), longissimus area (cm^2) and ham and loin yield (% of carcass) for the eight treatments were 3.33, 28.39, 37.64; 3.84, 25.05, 36.58; 3.51, 30.43, 39.15; 3.29, 29.46, 37.56; 3.01, 31.72, 39.61; 3.50, 28.60, 39.28; 3.59, 27.96, 38.16; and 3.59, 29.25, 38.55. Pigs fed 20% protein from 46 to 91 kg yielded significantly ($P<.05$) more ham and loin (% of carcass) than pigs fed 10% protein, but there was no significant differences among the other carcass traits. Backfat was significantly correlated with % ham and loin (r=-0.55), % lean cuts (r=0.52) and % fat trim (r=0.81).

Intramuscular fat (% of dry matter) of the gluteus medius and longissimus mucles, and taste panel scores (1 to 9, 9 = highest) for cured ham and fresh loin overall satisfaction were: 10.99, 13.88, 7.10, 7.44; 18.44, 28.95, 7.33, 7.88; 13.16, 18.50, 7.07, 7.41; 12.77, 22.40, 7.03, 7.54; 7.40, 9.93, 6.80, 7.31; 11.65, 16.32, 7.41, 7.23; 12.86, 16.20, 7.36, 7.43; and 15.93, 21.73, 6.84, 7.42.

Pigs fed 10% protein to 46 kg had significantly ($P<.05$) more intramuscular fat in the gluteus medius and longissimus muscles than pigs fed 20% protein. Correlations between backfat and intramuscular fat in the gluteus medius (r=.35) or longissimus (r=.02) were not significant ($P<.05$). There were no significant ($P<.05$) differences among treatments for taste panel acceptability. Correlations between intramuscular fat and taste panel scores were not significant ($P<.05$). The correlation between gluteus medius intramuscular fat and ham overall satisfaction was 0.32, and the correlation between longissimus intramuscular fat and fresh loin overall satisfaction was 0.48. Correlations between flavor, tenderness and overall satisfaction were high among ham or loin samples, but low between ham and loin samples.

EFFECT OF PROTEIN LEVEL ON INTRAMUSCULAR FAT IN SWINE

G. L. Cromwell, V. W. Hays, J. D. Kemp and W. G. Moody

An experiment involving 168 growing-finishing pigs was conducted to study the effect of dietary protein on intramuscular fat. Six protein sequences were each fed ad libitum to 4 pens of 4 Yorkshire and 3 pens of 4 Hampshire pigs from 23 to 53 kg (18 or 16% protein) and thereafter to 96 kg (16, 14 or 12% protein).

Intramuscular fat (IMF, % of dry matter) of the gluteus medius (GM), triceps brachii (TB) and longissimus dorsi (LD) tended to increase as protein level decreased, but the linear regression was significant only for the LD. IMF for pigs fed 18-16, 18-14, 18-12, 16-16, 16-14, 16-12 protein sequences were, respectively: GM, 10.24, 9.76, 12.25, 11.34, 11.21, 10.67; TB, 13.67, 12.64, 15.08, 14.65, 13.66, 13.61; LD, 14.23, 12.60, 16.45, 13.29, 15.24, 16.65. Yorkshire pigs had slightly higher levels of IMF in the GM (11.83 vs 9.68), TB (14.87 vs 12.57) and LD (14.87 vs 14.56) than Hampshires. The breed x protein level interactions were nonsignificant except for IMF in the LD.

Correlations adjusted for treatment and breed between backfat and IMF of the GM, TB and LD were 0.11, 0.07 and 0.10 and were not significant ($P<.05$). Correlations between IMF in the GM and TB, GM and LD and TB and LD were 0.32, 0.70 and 0.34, respectively.

EFFECT OF DIETARY FAT, CHOLESTEROL AND ASCORBIC ACID ON PERFORMANCE AND PLASMA CHOLESTEROL LEVELS IN SWINE

G. L. Cromwell and V. W. Hays

Fifteen pigs initially averaging 12.2 kg body weight were randomly assigned to three pens on the basis of weight within litter and sex. Ascorbic acid was added at levels of 0 or 1,000 mg/kg to 16% protein corn-soybean meal diets containing 10% tallow and 1% cholesterol. A third diet containing no fat, cholesterol or ascorbic acid served as a control. Each of the three diets was offered ad libitum for 35 days. Pigs were bled at the initiation and on the 35th day of the experiment. At the final bleeding blood samples were taken following a 16-hour fast and then at 2, 4, 8, 16 and 24 hours after feeding.

Tallow plus cholesterol addition did not affect gain (643 vs 659 g/day) but resulted in a slight reduction in the amount of feed required per unit of gain (2.24 vs 2.50). Gains were slightly improved

by ascorbic acid supplementation (656 vs 630 g/day) but feed/gain responses were unaffected (2.22 vs 2.25).

Plasma cholesterol levels were significantly ($P<.01$) elevated by the addition of tallow and cholesterol (1.66 vs 1.08 mg/ml) but were not significantly ($P<.05$) affected by ascorbic acid addition to diets containing fat and cholesterol (1.80 vs 1.53 mg/ml). The time after feeding had no significant influence on plasma cholesterol levels of pigs on any of the treatments. Average plasma cholesterol values for pigs bled following a 16-hour fast and at 2, 4, 8, 16 and 24 hr after feeding were 1.52, 1.48, 1.45, 1.42, 1.44 and 1.47 mg/ml, respectively. The within treatment correlation of initial and final cholesterol levels of the pigs was 0.43.

EFFECT OF ADDED THIOCYANATE AND IODINE TO CORN-SOYBEAN MEAL DIETS ON PERFORMANCE AND THYROID STATUS OF PIGS

D. T. H. Sihombing, G. L. Cromwell and V. W. Hays

Two experiments were conducted to study the effect of adding iodine and potassium thiocyanate to corn-soybean meal diets on performance and thyroid status of pigs. In experiment 1 a corn-soybean meal basal diet (B) containing technical-grade minerals with and without 0.5% potassium thiocyanate (A) and 0.2 ppm iodine (C) was fed in the following sequences for 28 and 23 days, respectively: (1) AA, (2) AB, (3) AC, (4) BB, (5) BC, (6) CC. Each treatment was imposed on four pigs, initially averaging 9.7 kg. Pigs were penned in stainless steel cages and had free access to diets and deionized water.

At 28 days pigs fed diets A and B had lower protein-bound-iodine (PBI, mcg/100 ml) levels than those fed diet C (0.45 and 0.86 vs 3.74). At 51 days pigs fed diet B had lower PBI levels, heavier thyroids and incorporated a higher percentage of ^{131}iodine in the thyroid than those fed diet C; however, gain and feed/gain were not markedly affected. Feeding of diet A resulted in slower and less efficient gains, reduced PBI levels and hypertrophy of the thyroid gland. At 51 days, gain (g/day), feed/gain, PBI, thyroid weight (g) and ^{131}iodine uptake by the thyroids (% of dose) were (1) 176, 2.58, 0.96, 13.5, 19.4; (2) 314, 1.84, 1.36, 14.4, 63.1; (3) 361, 2.02, 3.69, 6.4, 25.3; (4) 486, 2.11, 1.77, 12.9, 63.3; (5) 462, 2.21, 3.62, 4.0, 15.5; (6) 526, 2.21, 4.72, 2.2, 12.9.

In experiment 2, 80 pigs averaging 23.1 kg were fed corn-soybean meal diet with feed-grade minerals and containing (1) 0, (2) 0.1, (3) 0.2 or (4) 0.4 ppm iodine for 84 days. Pigs were housed in conventional pens and tap water was used. Gains, feed/gains and PBI levels were (1) 762, 3.36, 3.68; (2) 754, 3.28, 4.29; (3) 751, 3.36, 3.88; and (4) 760, 3.35, 4.24.

EFFECTS OF IODINE LEVELS, PROTEIN SOURCES AND GOITROGENS ON PERFORMANCE AND THYROID STATUS OF PIGS

D. T. H. Sihombing, G. L. Cromwell and V. W. Hays

Three experiments involving 68 pigs averaging 10.8 kg were conducted to study the effects of iodine on gain (g/day), protein-bound iodine (PBI, ug/100 ml) and thyroid weight (g/kg body weight). Pigs were penned in stainless steel cages and fed low iodine, semi-purified diets. In experiment 1, a basal diet containing isolated soya protein and containing Tapazole at a level of 750 ppm was fed for 31 days after which the Tapazole was withdrawn and iodine added at levels of 0.0, 0.1, 0.2 or 0.4 ppm. PBI levels decreased from 3.4 to 0.1 by 21 days but increased following Tapazole withdrawal, and at 14 and 29 days were 3.4, 4.2, 5.1, 6.0 and 5.0, 4.6, 4.8 and 6.4 for the four iodine levels, respectively. Thyroid weights decreased with added iodine (0.33, 0.25, 0.25, 0.21) but gains were not affected. Pigs fed Tapazole for 60 days gained only 1.5 kg and had lower PBI levels (0.6 vs 6.7) and larger thyroids (0.74 vs 0.09) than pigs fed a normal diet.

In experiment 2, diets containing isolated soya protein or casein with 0.0 or 0.2 ppm of added iodine were fed for 21 days following a 21-day depletion period with Tapazole. Iodine tended to improve gains, elevate PBI levels at both 7 and 21 days, and decrease thyroid weights in pigs fed both casein (530, 5.8, 3.5, 0.22 vs 502, 2.0, 2.9, 0.27) and soya (518, 6.3, 4.6, 0.21 vs 465, 2.0, 2.3, 0.35). Soya appeared to be more goitrogenic than casein as evidenced by lower PBI levels and greater thyroid size.

In experiment 3, a basal (soya) diet containing Tapazole or potassium thiocyanate (0.5%) was fed for 28 days after which the goitrogens were removed and iodine added at levels of 0.0 or 0.2 ppm. PBI levels decreased at a similar rate (from 7.2 to 1.4) for both goitrogens. Iodine addition improved gains, elevated PBI levels at 7 and 19 days and reduced thyroid weights of pigs fed either Tapazole (388, 6.6, 4.5, 0.18 vs 288, 2.1, 2.2, 0.34) or thiocyanate (502, 4.6, 4.8, 0.17 vs 357, 1.7, 2.2, 0.43) during the depletion period.

REPRODUCTIVE AND PROGENY PERFORMANCE OF PROTEIN RESTRICTED GILTS

M. J. DeGeeter, V. W. Hays, G. L. Cromwell and D. D. Kratzer

Diets calculated to contain 17 (high) or 2 (low) % protein were fed at a level of 1.82 kg per day to 21 and 20 gilts, respectively, from 15 days post-breeding to farrowing. Gestation weight gains were significantly ($P < .01$) greater for gilts fed the high protein level (19.4 vs 3.4 kg). Total and live pigs farrowed and birth weights (g) were similar for both groups: (high) 11.0, 10.2, 1,090; (low) 11.2, 10.6, 1,099. During lactation gilts were continued on low- and high-protein diets, with the low diet increased to 5% protein. Diets were fed ad libitum during lactation. Within 48 hr after parturition pigs from a "low" and "high" gilt were cross-fostered (not nursing their own dam) resulting in the following pig treatments: (1) high-high biological (nursing their own dam), (2) high-low fostered, (3) low-high fostered, and (4) low-low biological. Feed consumption (2.7 vs 4.8 kg/day) and weight loss (1.30 vs 0.21 kg/day) during lactation were significantly ($P < .01$) less for gilts fed the low-protein diet.

Pigs were weaned at 2 weeks of age and fed a starter diet calculated to contain 23% protein. Percent survival and gain (g/day) to 2 and 8 weeks of age were: 76.8, 66.7, 64.0, 67.4%; 221, 182, 198, 169 g and 54.5, 45.8, 42.2, 25.6%; 251, 244, 253, 231 g for treatments 1, 2, 3 and 4, respectively. Eight weeks after parturition 134 pigs (59, 30, 23 and 22 from the four treatments, respectively) were assigned to pens (three or four pigs/pen) and fed a common diet (19-16-13% protein) for 91 days. Daily gain (g/day) and feed required per unit of gain for the four treatments were respectively: 699, 713, 708, 667 g; 3.15, 3.15, 3.11, 3.11 g gained per g of feed.

Six pigs, averaging 28.6 kg, from each treatment were placed in individual metabolism cages for a 6-day nitrogen balance study. Grams of nitrogen retained/day, % retained of apparent nitrogen absorbed and apparent nitrogen digested (%) did not differ significantly ($P < .05$) and were 15.2, 14.6, 15.2, 14.2 g; 58.35, 58.78, 56.56, 56.33% and 84.21, 83.49, 83.84, and 82.71% for treatments 1 to 4, respectively.

AVOIDANCE AND WATER MAZE LEARNING ABILITY OF SWINE

D. L. Hammell, D. D. Kratzer, V. W. Hays and G. L. Cromwell

One-hundred twenty crossbred pigs (4 pigs randomly selected from each of 30 litters) were tested for learning ability at 3 weeks of age in a shock avoidance apparatus. At 7 weeks of age the pigs were tested in a three-choice-point water maze (30' x 8' x 2') used as a second measure of learning ability. Pigs from each litter were randomly allotted to maze patterns which were (1) left-left-left, (2) left-right-left, (3) right-left-right and (4) right-right-right.

Animals were tested three successive days with three trials daily. On day 1, pigs were conditioned to go through the maze by allowing left or right choices, and not permitting retracing. On day 2 the pigs were introduced to one of the four escape patterns.

The number of errors, correct responses and latencies (min) on the escape patterns were used as measures of maze learning ability. Mean number of errors, correct responses and escape latencies for the various patterns on day 3 were (1) 5.46, 9.13, 2.93; (2) 5.97, 9.40, 3.06; (3) 5.50, 9.30, 3.20; (4) 4.37, 9.30, 2.63, respectively. There were no significant ($P < .05$) differences observed in response of pigs to the four maze patterns. The correlation between errors and latency on day 3 was 0.71 ($P < .01$) and between correct responses and latency was 0.02. Correlations between avoidance scores and errors, correct responses and latencies on day 3 were not significant ($P < .05$).

EFFECT OF COPPER AND VITAMIN E ON RESPONSE OF PIGS FED CORN AND WHEAT BASE DIETS

V. W. Hays, G. L. Cromwell and R. O. Overfield

Two experiments involving 310 pigs were conducted to study the effects of supplemental copper and vitamin E on the performance of growing-finishing pigs. In the first experiment, three pens of five pigs averaging 21.4 kg were fed each of two diets including five levels of supplemental copper (0, 62, 125, 188 or 250 ppm) with or without added vitamin E (22 IU/kg).

During the first 42 days of the experiment there was a significant ($P < .05$) linear increase in rate of gain with increasing copper level in the diet. Average daily gain for the copper-supplemented pigs was 849 g/day as compared with 817 g/day for the controls. Vitamin E had no significant (P .05) effect on gain (867 vs 839 g/day) but did significantly decrease feed required per unit of gain (2.68 vs 2.75). For the entire experiment (to 94.1 kg) neither copper nor vitamin E level had a significant effect on gain, feed/gain or hemoglobin levels. The mean responses for pigs fed 0 vs all levels of copper were: gain, 840 vs 849 g/day; feed/gain, 3.25 vs 3.18; and hemoglobin, 13.2 vs 13.3 g/100 ml. The mean response to pigs fed diets containing no vitamin E vs added vitamin E were: gain, 841 vs 855 g/day; feed/gain, 3.21 vs 3.16; and hemoglobin, 13.3 vs 13.3 g/100 ml.

In the second experiment, four pens of five pigs each were fed each of eight diets in a 2 x 2 x 2 factorial arrangement of treatments including wheat vs corn, with or without vitamin E (22 IU/kg) and with or without copper (250 ppm). From an average pig weight of 16.3 to 96.6 kg, gain and feed/gain responses were similar for pigs fed wheat and corn diets (826 vs 808 g/day, 3.16 vs 3.16). Vitamin E had no significant influence on gain or feed/gain (813 vs 817 g/day, or 3.16 vs 3.15); however, supplemental copper significantly ($P < .05$) improved gain (831 vs 799 g/day) and feed/gain (3.11 vs 3.20).

None of the dietary variables significantly ($P < .05$) influenced hemoglobin or hematocrit values of the pigs. The interactions of copper x vitamin E, copper x grain sources and vitamin E x grain source were not significant ($P < .05$) for any of the criteria of response.

EFFECTS OF NEOMYCIN, TERRAMYCIN, CARBADOX AND OLEANDOMYCIN ON PERFORMANCE OF GROWING-FINISHING SWINE

G. L. Cromwell and V. W. Hays

An experiment involving 100 pigs was conducted to study the effects of Neomycin (165 mg/kg) and Terramycin (165 mg/kg) added singly and in combination and of Carbadox (55 mg/kg) on performance of young pigs from an average weight of 10.4 to 34.8 kg. A fifth diet with no antibiotic was used as a control. Pigs were randomly allotted to treatment from weight within sex outcome groups, and each diet was offered to four pens of five pigs each. Corn-soybean meal diets calculated to contain 18% protein were used.

After an average of 38.5 days on test at which time the pigs averaged 34.8 kg, one-half of the pigs were switched to diets containing Oleandomycin (11 mg/kg), and the remaining pigs were fed a control diet with no antibiotic. When the pigs were at an average weight of 58.1 kg, the Oleandomycin level was reduced to 6.6 mg/kg. Protein levels during this phase of the study were 16 and 14%, respectively. The experiment was terminated as pigs reached 93 kg on weekly weighings.

Results of the initial phase of the experiment are summarized in Table 1. Pig gains were improved by the addition of antibiotics to the diets. Pigs fed the Neomycin-Terramycin combination gained significantly (P .05) faster than those fed either of the two antibiotics singly. Pigs fed Carbadox gained similarly as did those fed the Neomycin-Terramycin combination. Feed required per unit of gain tended to decrease when antibiotics were added to the diet but the differences were not significant ($P < .05$).

Gains and feed/gain responses of pigs during the latter stage of the experiment are summarized in Table 2. Pigs fed Oleandomycin gained slightly faster and had lower feed/gain response than those fed the control diet; however, the differences were not significant ($P < .05$). The interactions between treatments imposed during the initial and final stages of the experiment were small and nonsignificant.

Table 1.—Effects of Various Antibiotic Combinations for Pigs from 10.4 to 34.8 kg Bodyweight

	Treatment				
	Control	Neomycin	Terramycin	Neomycin + Terramycin	Carbadox
	-	165 mg/kg	165 mg/kg	165 and 165 mg/kg	55 mg/kg
Average daily gain, g	578	601	619	677	667
Feed/gain	2.25	2.14	2.23	2.17	2.15

Table 2.—Effect of Oleandomycin for Pigs from 34.8 to 96.5 kg Bodyweight

	Treatment	
	Control	Oleandomycin[a]
Average daily gain, g	750	764
Feed/gain	3.21	3.16

[a] 11 mg/kg from an average weight of 34.8 to 58.1 kg and 5.5 mg/kg thereafter to 96.5 kg.

EFFECT OF ARSANILIC ACID AND VITAMIN E ON PERFORMANCE OF GROWING-FINISHING SWINE

G. L. Cromwell, V. W. Hays and T. W. Cathy

A 2 x 2 factorial experiment was conducted to determine the effects of level of arsanilic acid (0 vs 99 mg/kg) added to diets with and without supplemental vitamin E (22 IU/kg). Corn-soybean meal diets formulated to contain 16% protein were fed pigs having an average initial weight of 24.3 kg until the average weight reached 54.7 kg, after which the protein level was reduced to 14%. Each diet was offered ad libitum to three replicate pens of three or four gilts each for 87 days. Average final weight of the pigs was 89.5 kg.

Results are summarized in Table 1. Rate of gain and feed required per unit of gain were not significantly ($P < .05$) affected by adding vitamin E (754 vs 745 g/day, 3.11 vs 3.19) nor by adding supplemental arsanilic acid (736 vs 763 g/day, 3.16 vs 3.15). The vitamin E x arsanilic acid interactions for both rate and efficiency of gain were small and nonsignificant ($P < .05$).

Table 1.—Effect of Vitamin E and Arsanilic Acid on Performance of Growing-Finishing Swine

Vitamin E, IU/kg	0	22	0	22
Arsanilic Acid, mg/kg	0	0	99	99
Average daily gain, g	763	763	726	745
Feed/gain	3.20	3.09	3.18	3.13

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