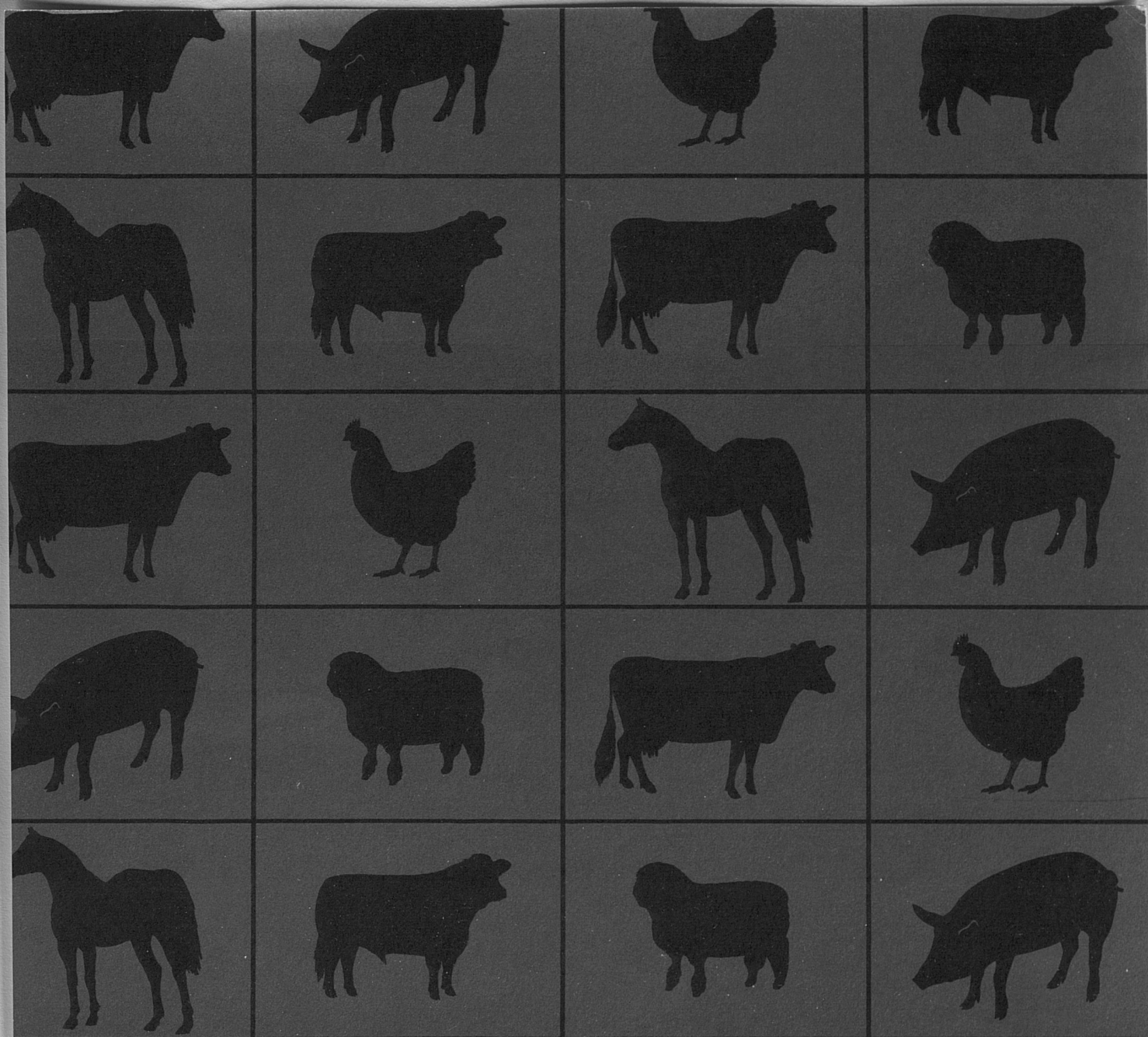


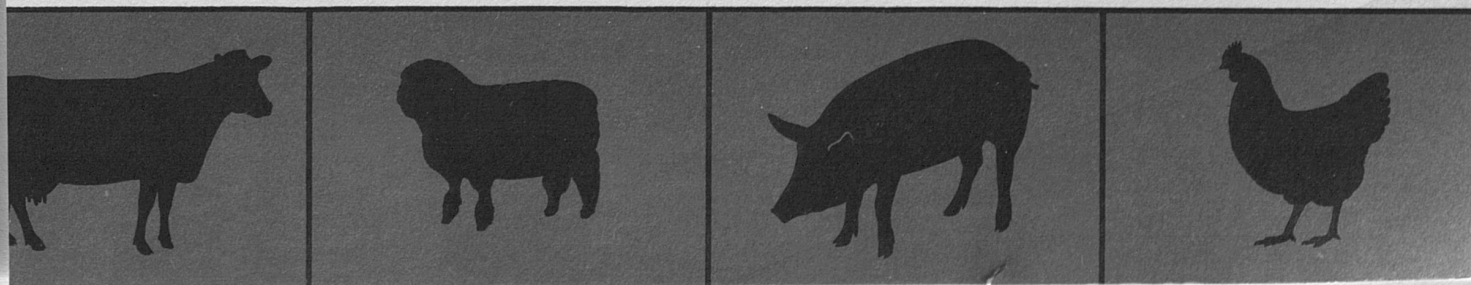


Animal Sciences Research Report

1969

UNIVERSITY OF KENTUCKY * AGRICULTURAL EXPERIMENT STATION

Progress Report 181



PROGRAMS FOR 1969 ANIMAL SCIENCES FIELD DAYS

July 16, 1969 - University Coldstream Farm, Lexington
July 18, 1969 - Western Kentucky Substation Farm, Princeton

- Conducted tours of beef, sheep, and swine research at regular intervals beginning at 9:00 a.m.
- Lunch provided by Bluegrass Stockyards, Lexington, and Field Packing Company and Owensboro Milling Company, Owensboro
- Address -- "Livestock Potential of Kentucky" - Charles E. Barnhart, Dean and Director, College of Agriculture, University of Kentucky

KENTUCKY
ANIMAL SCIENCES RESEARCH REPORTS
1969

Progress Report 181

July 1969

UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

CONTENTS

<u>ANIMAL FOODS</u>	Page
Effect of Castration and Slaughter Weight on Lamb Carcass Characteristics	5
Performance and Carcass Characteristics of Rams and Wethers Slaughtered at Different Weights	8
Effects of Rate of Gain, Slaughter Weight and Castration on Selected Chemical, Histological and Organoleptic Characteristics of Ovine Muscle and Adipose Tissue	9
Physical, Chemical and Histological Properties of Low, Medium and High Quality Hams at Various Intervals During Curing and Aging	12
Hardening Ice-cream by Immersion in Liquid Nitrogen	14
<u>ANIMAL NUTRITION</u>	
Effect of Dietary Calcium and Phosphorus Level on Performance, Carcass Characteristics and Bone Mineralization of Swine	15
Copper, Molybdenum and Sulfate Interrelationships in Swine	15
Effects of Continuous Feeding of 2, 2-Dichlorovinyl Dimethyl Phosphate (DDVP) on Performance of Growing-Finishing Pigs	16
Effects of Aureomycin and Copper Sulfate on Performance of Growing-Finishing Pigs	17
Effects of Spectinomycin on Performance of Growing-Finishing Pigs	17
Effects of Carbadox on the Performance of Growing-Finishing Pigs	18
Growth and Digestibility Studies with <u>Opaque-2</u> and Normal Corn for Growing Pigs	19
Effects of Dietary Protein and Fat on Intramuscular Fat and Backfat Thickness of Swine	20
Effect of Protein Level on Performance and Carcass Characteristics of Growing-Finishing Swine	20
Comparison of Corn and Wheat in Diets for Growing-Finishing Swine	23
Effect of Dietary Ascorbic Acid on Performance of Growing-Finishing Swine	23
Effect of Evaporative Cooling on the Performance of Finishing Swine	24
Bluegrass-ladino Clover and Sorghum-sudan Hybrid for Grazing Steer Calves	24
Creep Feeding Spring and Fall Calves	25
Energy and Protein Supplements for Wintering Yearling Stocker Steers	26
Effect of Limited Water Intake on Feed Consumption and Nutrient Digestibility	27
Feedlot Performance of Steers Fed Two Levels of Urea	29
Nitrogen Sources for Feedlot Steers Fed Ground Ear Corn Rations	30

<u>ANIMAL NUTRITION</u> (continued)	Page
Level of Feed Intake and Molasses Additions to Urea Rations for Feedlot Steers	32
Soybean Meal and Urea in Steer Finishing Rations	32
Soybean Meal, Urea and No Supplementary Nitrogen Comparisons for Steers Fed Corn Silage	34
Feeding Behavior of Steers Fed Soybean Meal and Urea Supplemented Diets	35
Nitrogen in the Digestive Tract of Steers Fed Soybean Meal or Urea	36
Amino Acids in Plasma of Steers Fed Different Nitrogen Sources	37
Digestion of Cellulose Infused into the Abomasum of Steers	39
Rumen Stimulatory Properties of Proline	40
Various Physical Measurements as Indicators of Fat in Cows	41
Turnover of Vitamin A Stores in Mature Beef Steers	42
Liver Vitamin A Turnover in Mature Rams	42
Influence of Corn Oil on Pre-intestinal Disappearance of Vitamin A in Sheep	43
Plasma and Urinary Components in Vitamin A-Deficient Ewes	43
Amylase Activity in the Pancreatic Secretions of Sheep Following Glucose Infusions	45
Digestion of Cellulose Infused into the Cecum of Lambs	46
Digestion of Cellulose and Mixtures of Corn Oil and Cellulose Infused into the Cecum of Wethers	46
Oral and Abomasal Administration of Lysine to Wethers	47
Amino Acids in Plasma of Early Weaned Lambs	48
Grass Hays for Pregnant and Lactating Ewes	48
Roughage Levels in Rations for Early-weaned Lambs	49
Factors Affecting Rumen Microbial Activity in Young Lambs	50
Urea or Heated Soybean Meal for Young Lambs	52
Urea for Lambs From Birth to Market	53
Amino Acids in Equine Cecal Contents, Cecal Bacteria and Serum	55
Hepatic Utilization of Glucose and Volatile Fatty Acids in the Equine	56
Liquid Supplements for Lactating Dairy Cows	57
Synthesis and Physiological Requirements of Amino Acid for Lactating Cows	59
Development of Methods for Relating Forage Properties to Intake and Digestibility	59
Bioassay, Isolation, Identification of Toxic Factor(s) in Tall Fescue and Vasoactive Mycotoxins Associated with Tall Fescue	59

GENETICS AND PHYSIOLOGY

	Page
Synchronization of Estrus of Gilts with Aimax, PMS and HCG	61
Effect of 2, 2-Dichlorovinyl Dimethyl Phosphate (DDVP) on Reproductive Performance of Swine	62
When Should Dairy Heifers Be Bred for First and Second Calves?	63
Molecular, Ionic, and Cellular Migrations in Freezing Solutions and Their Effects on Sperm Survival	64
Effect of Sire on Certain Carcass Traits of Young Bulls	65
Effect of Sire, Sex and Sire X Sex Interactions on Beef Cattle Performance and Carcass Traits	67
Seasonal Variation in Free Amino Acid Concentration in Seminal Plasma of Rams	70
Motility of Ram Spermatozoa After Storage in Glycerol or Propylene Glycol Dilutors at 4° and -40°C	71
Effect of Vaginal Sponges and PMS on Reproductive Performance in Spring-bred Yearling and Aged Crossbred Ewes	72
Relationship Between Gestation Length and Number of Lambs Born	73
Use of Hormones to Stimulate Breeding Activity in Anestrous Yearling Ewes	73
Semen Characteristics of Southdown Rams Fed a Chlorohydrin (3-Chloro-1,2-Propanediol)	75
Sources of Variation in Semen Characteristics of Yearling Southdown Rams	76
Influence of the Photoperiod on Ovulation, Fertility and Embryo Survival Rates in Ewes	77

ANIMAL FOODS SECTION

EFFECT OF CASTRATION AND SLAUGHTER WEIGHT ON LAMB CARCASS CHARACTERISTICS

James D. Kemp, J. D. Crouse, Winston Deweese and W. G. Moody

The relationship of castration to carcass composition and meat quality has been elucidated only partially. This is particularly true as it applied to lambs slaughtered at different weights. This study, therefore, was designed to study the effects of castration and slaughter weight on lamb carcass characteristics.

Thirty crossbred ram lambs and 30 similar wether lambs (castrated before 10 days of age) were placed on feed in dry lot at 18 kg and assigned in equal numbers to slaughter weights of 36, 45 and 54 kg. Lambs were slaughtered, and the carcasses were chilled 48 hours, graded, weighed, measured, and cut into wholesale cuts, retail cuts and edible portions. One leg from each carcass was dissected into fat, lean and bone. Total carcass composition was calculated.

Live animal and carcass weights are given in Table 1. Although live weights were similar for rams and wethers in each weight group the carcass weights were greater for wethers, indicating higher dressing percents (50.0 vs 48.4) for wethers. Testicles (lamb fries) weigh about 3/4 of 1% of live weight. If they were included in dressing percentage the difference between rams and wethers would be reduced. Since the wholesale price per pound of lamb fries is approximately twice that of carcasses, the value of ram carcasses plus fries is approximately equal to the value of wether carcasses from lambs of equal weight.

Age at slaughter was significantly ($P < .01$) less for rams. This resulted in significantly ($P < .01$) more carcass weight per day of age for rams despite the fact that wethers had heavier carcasses. Carcass grades were similar for rams and wethers, but grades were higher for heavier carcasses although all graded prime or choice.

Carcass measurements dealing with fatness including width behind shoulders, fat thickness over eye muscle, over spinous process and over ribs were significantly greater for wethers than for rams.

There were only minor differences in percent wholesale cuts owing to sex. There were, however, some significant differences owing to weight. Percent leg, shank and kidney decreased ($P < .01$), and percent breast and flank and kidney fat increased ($P < .01$) with an increase in weight. There were major differences in percent retail cuts owing to both weight and sex (Table 2). As weight increased, percent retail cuts decreased ($P < .01$), owing to extra fat trim in heavier carcasses. Percent retail cuts from rams was significantly ($P < .01$) greater than for wethers. This was also related to fatness as shown by the fat trim for the different groups.

Percent edible portion and percent bone followed the same pattern as did percent retail cuts. As fatness increased owing to either weight or sex, the percent of edible meat decreased. Fat trim was in inverse relationship to edible portion and bone. When expressed as actual weight rather than percent the differences were much greater for fat trim than for bone.

Dissection of the leg revealed that there was a significant ($P < .01$) increase in percent fat and corresponding decrease in lean and bone as weight increased. Legs from rams had a significantly higher percent lean and bone and lower percent fat than did wethers. These same trends followed when total carcass composition was calculated.

Conclusions

Wethers had higher dressing percentages than did rams, but the differences were reduced when testicle weights were included. Value of ram carcasses plus testicles was

Table 1. — Live Animal and Carcass Traits

Sex	Wt Group, kg	Slaugh- ter Age, Days	S.D.	Live Wt, kg	S.D.	Cold Carcass Wt, kg	S.D.	Carcass Wt/Day Age, gm	S.D.	Grade ^{a/}	S.D.	Dr %
Ram	36	105.6	8.3	36.2	1.2	17.0	0.8	162	13	11.8	0.6	47.0
	36	124.1	14.7	36.3	0.7	17.6	0.6	143	15	12.1	0.7	48.5
Ram	45	129.0	11.6	44.6	0.8	21.5	0.9	168	14	13.6	1.1	48.2
Wether	45	132.7	13.7	44.9	0.8	22.7	0.9	172	17	13.8	1.3	50.6
Ram	54	155.0	13.2	54.2	1.2	26.9	1.3	175	12	13.7	1.1	49.6
Wether	54	167.5	11.5	54.4	1.5	27.6	1.2	166	8	14.2	1.1	50.7
Combined	36	114.8 ^{b/}	15.0	36.2 ^{b/}	1.0	17.3 ^{b/}	0.7	153 ^{b/}	17	11.9 ^{b/}	0.7	47.8
Combined	45	130.9	12.5	44.7	0.8	22.1	1.1	170	15	13.7	1.2	49.4
Combined	54	161.2	13.6	54.3	1.3	27.3	1.3	170 ^{c/}	11	13.9	1.1	50.3
Ram	Combined	129.9 ^{b/}	23.2	45.0	7.6	21.8 ^{b/}	4.2	168 ^{b/}	14	13.0	1.3	48.4
Wether	Combined	141.5	23.0	45.2	7.6	22.6	4.3	160	18	13.4	1.4	50.0

^{a/} 14 = Prime, 13 = Prime -, 12 = Choice +, 11 = Choice^{b/} P < .01^{c/} P < .05 for interaction between weight and sex

Table 2. — Carcass and Leg Components

		Carcass Components				Leg Components			Calculated Carcass Composition ^{a/}		
		Retail Cuts, %	Edible Portion, %	Fat Trim, %	Bone %	Fat %	Lean %	Bone %	Fat %	Lean %	Bone %
Rams	36	88.0	69.0	11.0	19.7	18.3	65.7	15.7	25.7	57.4	15.8
Wethers	36	86.7	67.0	14.0	18.8	19.9	65.0	15.0	27.4	56.8	15.1
Rams	45	86.7	66.8	14.7	17.7	20.8	64.5	14.5	28.3	56.3	14.6
Wethers	45	83.2	65.0	18.5	16.3	23.5	62.6	13.5	31.2	54.6	13.7
Rams	54	82.9	65.0	19.0	15.8	24.1	62.5	13.0	31.9	54.5	13.2
Wethers	54	78.0	60.8	24.0	14.9	26.6	60.2	12.8	34.6	52.4	13.0
Combined	36	87.4 ^{b/}	68.0 ^{b/}	12.5 ^{b/}	19.3 ^{b/}	19.1 ^{b/}	65.3 ^{b/}	15.3 ^{b/}	26.5	57.1	15.4
Combined	45	85.0	65.9	16.6	17.0	22.1	63.6	14.0	29.8	55.5	14.2
Combined	54	80.4	62.9	21.5	14.4	25.4	61.4	12.9	33.3	53.5	13.1
Rams	Combined	85.9 ^{b/}	67.0 ^{b/}	14.9 ^{b/}	17.7 ^{b/}	21.1 ^{b/}	64.2 ^{b/}	14.4 ^{b/}	28.6	56.1	14.5
Wethers	Combined	82.6	64.2	18.8	16.7	23.3	62.6	13.8	31.0	54.6	14.0

^{a/} Using equations developed by Latham et al. 1966, J. Animal Sci. 25, 492.

^{b/} $P < .01$

^{c/} $P < .05$

similar to value of wether carcasses. Rams had more carcass weight per day of age. Wether carcasses were fatter as denoted by measurements, more fat trim, lower retail and edible portion yields and more fat in legs. Heavier carcasses in both sex groups were fatter and had lower yields of retail cuts and edible portion and higher yields of fat trim. The increase in fatness and decrease in retail yield and edible portion was greater in wethers than in rams as carcass weight increased. Castration had no effect on carcass grade.

PERFORMANCE AND CARCASS CHARACTERISTICS OF RAMS AND WETHERS SLAUGHTERED AT DIFFERENT WEIGHTS

W. P. Deweese, H. A. Glimp, J. D. Kemp and D. G. Ely

Although a trend has developed toward marketing lambs at heavier weights, some research data suggest a high positive relationship between weight of lamb and amount of fat. The following experiment was designed to compare the performance of rams versus wethers slaughtered at different weights and to correlate performance with loin-eye area, percent fat in the rack, and the fat thickness over the 12th rib.

Sixty Hampshire-sired crossbred lambs (30 rams and 30 wethers) were weaned at 18.1 kg (40 lb) and fed a high concentrate pelleted ration in pens of five lambs each. Lambs were assigned to slaughter groups with one-third slaughtered at live weights of 36.2, 45.3, and 54.4 kg (80, 100, and 120 lb). They were weighed weekly until they reached slaughter weight. They were then slaughtered and carcass measurements were taken. Average daily gain and feed consumption were measured for every 9.1 kg increment from 18.1 kg to slaughter.

Rams consistently gained faster on less feed than did wethers for each 9.1 kg increment. Rams gained a maximum of 0.415 kg per head daily from 36.2 to 45.3 kg, while wethers gained a maximum of 0.352 kg for the 36.2 to 45.3 growth period. Loin-eye areas for rams and wethers were, respectively: 13.50 sq cm, 12.85 sq cm (36.2 kg lambs); 14.18 sq cm (45.3 kg lambs); and 17.83 sq cm, 15.29 sq cm (54.4 kg lambs). Wethers had greater fat thickness over the 12th rib at all three slaughter weights than did rams.

Table 1. — Average Daily Gain and Feed Consumption at Different Weights

Weight (kg)	Average Daily Gain (kg)		Feed/Gain (kg)	
	Rams	Wethers	Rams	Wethers
Birth 18.1				
18.1 - 27.2	0.321	0.279	3.71	4.26
27.2 - 36.2	.402	.348	4.98	5.76
36.2 - 45.3	.415	.352	5.67	6.43
45.3 - 54.4	.338	.315	7.57	8.13

Table 2. — Fat Measurements in Ram and Wether Carcasses

Slaughter Wt, kg	Percent Fat in Rack		Backfat Thickness (mm)	
	Rams	Wethers	Rams	Wethers
36.2	10.57	15.31	3.9	5.0
45.3	16.15	19.65	4.9	7.9
54.4	18.38	28.61	6.9	11.0

EFFECTS OF RATE OF GAIN, SLAUGHTER WEIGHT AND CASTRATION ON SELECTED CHEMICAL, HISTOLOGICAL AND ORGANOLEPTIC CHARACTERISTICS OF OVINE MUSCLE AND ADIPOSE TISSUE

Doris Tichenor, James D. Kemp, W. G. Moody, J. D. Fox and Winston Deweese

The amount of lamb consumed in the United States has declined in recent years, although total annual meat consumption has risen steadily. Efforts to improve consumer acceptance of lamb have centered around identifying the desirable lamb carcass and improving the quality factors which lead to eating satisfaction. Ways of increasing the yield of edible meat have also been sought.

The objectives of this study were: (1) to examine the effects of slaughter weight and rate of gain upon lamb fatty acid composition, muscle fiber size, shrinkage during cooking, and palatability; and (2) to determine whether there are significant differences between rams and wethers with respect to these characteristics.

Two experiments involving 132 lambs were conducted during a 2-year period. Experiment I included 72 wethers randomly divided into 3 groups, to be slaughtered at light (36 kg), medium (45 kg), and heavy (54 kg) weights. Experiment II included 30 rams and 30 wethers with each sex equally divided into light, medium and heavy slaughter weight groups. Within each weight, the lambs were sorted equally as fast and slow gainers on the basis of average daily gain from 27 kg to slaughter. The animals were slaughtered as they reached the desired weights, and samples were taken for the planned analyses.

Myristic, palmitic, stearic, oleic, linoleic and linolenic acids were determined in perinephric and subcutaneous adipose tissue by gas-liquid chromatography. Histological measurements of muscle fiber diameter, intramuscular fat cell size, and relative abundance of intramuscular fat were made on *longissimus dorsi* and *semitendinosus* muscles. A rack from each lamb was roasted and cooking losses, palatability, and shear values were determined. The data were subjected to analysis of variance and simple correlation analysis.

Results and Discussion

Levels of myristic and oleic acids in perinephric adipose tissue decreased and levels of palmitic acid increased with increasing weight of the animals (Table 1). The perinephric fat of slow-gaining heavy wethers contained higher levels of stearic acid than that of comparable fast-gaining wethers. Stearic acid generally increased as oleic acid decreased. The fatty acid composition of subcutaneous adipose tissue was not affected by slaughter weight or rate of gain.

Table 1. — Average Weight Percents of Six Fatty Acids in Perinephric Adipose Tissue^{a/}

Fatty Acid	Slaughter Weight					
	Experiment I			Experiment II		
	Light	Med	Heavy	Light	Med	Heavy
	(Percent)					
Myristic	3.0	2.8	2.8	3.3 ^x	2.9 ^{xy}	2.7 ^y
Palmitic	19.3 ^x	20.2 ^{xy}	21.2 ^y	19.6	19.6	20.9
Stearic	27.4	28.0	27.6	27.8	27.7	28.3
Oleic	42.3 ^s	40.7 ^{sr}	40.5	38.8	36.9	37.2
Linoleic	6.0	6.3	6.0	7.6	8.3	8.2
Linolenic	2.1	1.9	1.9	2.8	2.7	2.6

^{a/} Within each category, means on the same line having different superscripts differ significantly; s and r are used for $P < .05$ and x and y are used for $P < .01$. Sets of means without superscripts are not significantly different.

Both perinephric and subcutaneous fat of rams contained less stearic acid and more linoleic and linolenic acids than comparable fat of wethers (Table 2). The ram fat contained a higher proportion of unsaturated 18-carbon fatty acids.

Table 2. — Average Weight Percents of Six Fatty Acids in Subcutaneous and Perinephric Adipose Tissue of Rams and Wethers^{a/}

Fatty Acid	Subcutaneous		Perinephric	
	Rams	Wethers	Rams	Wethers
	(Percent)			
Myristic	5.3	5.2	3.0	2.9
Palmitic	23.2 ^{s/}	24.3 ^{r/}	19.5	20.5
Stearic	16.2 ^{s/}	17.9 ^{r/}	26.8 ^{x/}	29.1 ^{y/}
Oleic	42.7 ^{s/}	41.4 ^{r/}	38.2	37.1
Linoleic	9.2 ^{x/}	7.9 ^{y/}	8.8 ^{x/}	7.3 ^{y/}
Linolenic	3.4	3.5	2.9 ^{x/}	2.5 ^{y/}
Total unsaturated	55.2	52.8	50.0	46.8

^{a/} See footnote ^{a/}, Table 1

Muscle fibers of the semitendinosus were larger in heavy lambs than in the lightweight animals (Table 3). The average l. dorsi fiber diameter was also greater in the heavy lambs (Exp. II), the increase being largely attributable to the rams. Average fat cell diameter was larger in the l. dorsi than in the semitendinosus (Table 3), and the l. dorsi fat cell size was larger in heavy animals than in medium and lightweight animals.

Table 3. — Average Fiber and Fat Cell Diameters (microns) of semitendinosus and l. dorsi muscles^{a/}

Item	Slaughter Weight					
	Experiment I			Experiment II		
	Light	Medium	Heavy	Light	Medium	Heavy
	(Microns)					
Fiber diameter, <u>semitendinosus</u>	37.9 ^{x/}	44.0 ^{y/}	42.7 ^{y/}	38.0 ^{s/}	39.8 ^{sr/}	43.8 ^{r/}
Fiber diameter, <u>l. dorsi</u>	38.1	39.0	39.9	34.6	38.5	40.3
Fat cell diameter, <u>semitendinosus</u>				55.3	50.7	60.9
Fat cell diameter, <u>l. dorsi</u>				54.5 ^{s/}	54.5 ^{s/}	65.2 ^{r/}

^{a/} See footnote ^{a/}, Table 1.

Total shrinkage losses were highly variable among animals, but the percentage of shrinkage loss as drippings increased with increasing weight (Table 4). Roasts from slow-gaining lambs had more weight loss from drippings than those from fast gainers, and roasts from wethers had more than those from rams.

Table 4. — Weight of Drippings from Roasted Racks as a Percent of Total Weight Loss During Cooking^{a/}

Item	Experiment I	Experiment II
Slaughter weight		
Light	23.6 ^{x/}	18.5 ^{x/}
Medium	30.7 ^{y/}	23.6 ^{y/}
Heavy	41.7 ^{z/}	33.1 ^{z/}
Rate of gain		
Fast	29.7 ^{x/}	23.5 ^{x/}
Slow	34.3 ^{y/}	26.7 ^{y/}
Sex		
Rams		21.5 ^{x/}
Wethers		28.6 ^{y/}

^{a/} Within each category, means in the same column having different superscripts differ significantly ($P < .01$).

Flavor and juiciness of roasted l. dorsi muscles were not affected by slaughter weight, rate of gain or sex. The flavor of all roasts was considered acceptable, and meat from the heavy lambs was as well-liked as that from the younger, lightweight lambs. Meat from rams and wethers was equally desirable in flavor and juiciness.

Tenderness of roasted racks from wethers increased with increasing weight (Table 5). Roasts from wethers had a higher average tenderness score than roasts from rams, but all were acceptable. Warner-Bratzler shear values were negatively correlated with tenderness ($P < .01$).

Table 5. — Average Palatability Panel Scores for Tenderness of Roast Lamb^{a, b/}

Item	Experiment I	Experiment II
Slaughter weight		
Light	7.1 ^{s/}	7.1
Medium	7.6 ^{r/}	6.9
Heavy	7.8 ^{r/}	7.5
Rate of gain		
Fast	7.5	6.9 ^{x/}
Slow	7.5	7.5 ^{y/}
Sex		
Rams		6.9 ^{x/}
Wethers		7.5 ^{y/}

^{a/} Scores were assigned on a 10-point rating scale where 10 = excellent and 1 = very poor.

^{b/} Within each category, means in the same column having different superscripts differ significantly; s and r are used for $P < .05$ and x and y are used for $P < .01$. Sets of means without superscripts are not significantly different.

General acceptability scores were highly correlated with flavor, juiciness and tenderness, but tenderness appeared to be the most important determinant of acceptability.

Positive correlations ($P < .01$) were obtained between tenderness and percent weight lost from drippings, indicating that loins containing larger amounts of fat were more tender.

Fiber diameters of the semitendinosus and l. dorsi muscles were unrelated to sensory tenderness.

PHYSICAL, CHEMICAL AND HISTOLOGICAL PROPERTIES OF LOW, MEDIUM AND HIGH QUALITY HAMS AT VARIOUS INTERVALS DURING CURING AND AGING

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

Much work has been done comparing pale, soft, exudative (PSE) pork with normal pork. Only a small amount of work, however, has been reported comparing dry-cured hams from fresh hams of varying quality groups. This study was designed, therefore, to compare certain physical, chemical and histological properties of dry-cured hams at various intervals during curing and aging.

Thirty pairs (60 total) of fresh hams were equally divided into three groups of low, medium and high quality hams based on the Wisconsin pork quality standards. All hams were cured at 2° to 4° C for 2 days per lb, using 10 lb of curing mixture per 100 lb of fresh hams. An additional period of 30 days was provided for salt equalization. Hams were then smoked in a conventional smoker until brown. Aging was accomplished in a controlled temperature and humidity room at 75° F and 65%, respectively. The biceps femoris muscle of each right ham was sampled fresh, after salt equalization and after 2 and 4 months' aging for physical, chemical, and histological observations. The left hams were used as controls and weighed at designated intervals to determine shrinkage. At the end of the 4 months' aging period the left ham of each group was cut and scored for aroma and soundness. In addition, a palatability test and Warner-Bratzler shear analysis were determined on the same muscle of each left ham.

Results of the histological studies are shown in Table 1. The percent red fibers per bundle was slightly less, but fiber size was slightly larger in the low quality group. The difference in size and numbers of red fibers per muscle bundle seemed to be directly related to capillary numbers and total blood supplying the muscle. Both intrafiber and intrafascicular fat were evaluated microscopically, using low magnification. In general, the low quality hams possessed less intramuscular fat than the high quality hams. The number of fibers per bundle was determined by counting both red and white fibers in each of five secondary bundles which contained less than 70 total fibers. Selecting relatively small bundles helped reduce the counting error.

The pH of the fresh muscle was not significantly different among groups. However, a slightly lower pH was observed in the low quality group (Table 2). Expressible juice was determined by the filter paper press method, and the low quality group had a significantly ($P < 0.01$) higher percent expressible juice than did hams in group 3 when fresh and after salt equalization. There were no significant differences after aging 2 and 4 months. These data reveal the extremely poor water-binding ability of PSE muscle. There was no significant difference in moisture or salt content among groups. High quality hams contained more ether extractable fat and myoglobin on a fresh basis than did hams of either medium or low quality.

Results of the palatability and shrinkage data are shown in Tables 3 and 4 respectively. Hams with low quality scores (1) were rated significantly lower ($P < 0.01$) in flavor and overall satisfaction by the taste panel. There was no significant difference in tenderness among groups as noted by either the panel or the WB shear. However the low quality groups tended to be slightly more tender. The low quality hams shrank significantly ($P < 0.01$) more during curing and aging than the high quality group.

Table 1. — Histological Determinations

Variables	Group 1 ^{a/}	Group 2 ^{b/}	Group 3 ^{c/}
Red fibers, %	39.8	44.0	43.5
Fiber No./bundle, Sec. ^{d/}	47.0	49.0	50.0
Fiber size, μ	75	72	73
Intrafiber fat ^{e/}	slight	slight	small
Interfascicular fat ^{e/}	traces	small	moderate

^{a/} Group 1 - Low quality hams (PSE). Muscles extremely pale, soft and watery.

^{b/} Group 2 - Medium quality hams. Muscles pale, moderately soft and moderately watery.

^{c/} Group 3 - High quality hams. Muscles uniformly grayish pink, moderately firm and moderately dry.

^{d/} Fiber numbers per bundle determined on 5 secondary bundles with less than 70 total fibers.

^{e/} Relative amounts of intramuscular fat as determined by ocular grid at low magnification. 63X.

Table 2. — Selected Fresh Ham Variables

Variable	Group 1	Group 2	Group 3
pH ^{a/}	5.63	5.69	5.83
Expressible juice ^{b, d/}	10.92	10.02	9.14
Moisture, % ^{a/}	72.91	71.34	71.10
Ether extract, % ^{a, d/}	5.68	6.93	7.79
Myoglobin ^{a, c/}	0.51	.55	.71

^{a/} Taken on biceps femoris muscle.

^{b/} Reported as square inches of expressible juice on No. 2 filter paper when a 2 gm sample was subjected to 50 lb pressure for 5 minutes.

^{c/} $P < 0.05$

^{d/} $P < 0.01$

Table 3. — Palatability Data

Quality Groups	Panel ^{a/}	Tenderness		Saltiness ^{a/}	OS ^{a, c/}
		W-B ^{b/}	Flavor ^{a/}		
1	7.08	13.12	4.80	6.29	4.95
2	7.17	13.84	6.11	6.42	6.05
3	6.91	17.02	6.58	6.69	6.54

^{a/} Based on 9-point hedonic scale.

^{b/} W-B = Warner-Bratzler shear, lb force to shear one-inch cores

^{c/} OS = Overall satisfaction

Table 4. — Percent Shrinkage of Hams by Periods

Quality Groups	Out of Cure	Out of Salt Eq	Out of Smoke	Aging periods			
				1 Mo	2 Mo	3 Mo	4 Mo
1	5.53	11.87	12.43	20.0	23.2	26.0	28.3
2	4.07	10.92	11.57	18.6	21.64	24.4	26.6
3	3.36	9.47	10.20	16.5	19.77	22.4	24.2

Summary

PSE muscle selected from the *biceps femoris* of low quality hams had slightly fewer but larger red fibers per muscle bundle than similar muscle fibers from high quality hams. Similarly, the low quality hams contained less microscopic and ether extractable fat than high quality hams. The pH was slightly lower and the expressible juice much higher in the low quality group. Additionally, low quality hams were slightly more tender but less flavorful, and shrank significantly more than high quality hams during curing and aging.

HARDENING ICE-CREAM BY IMMERSION IN LIQUID NITROGEN

A. W. Rudnick, I. J. Ross* and J. D. Fox

Exposing ice-cream to liquid nitrogen for hardening could have several advantages, both physically and economically. The experiments were undertaken to learn if the rapidity of hardening of ice-cream would have any effect on body and texture of the product when served at normal temperatures.

Ice-cream made by both batch and continuous process was hardened by submerging round 1/2 gallon containers of the product in liquid nitrogen. Thermocouples were placed at the outside carton surface, inside carton surface, mass average** and center. Time of immersion varied from the period required to reach -28.9 C at mass average to the time required for the center to approach -195.6 C (3 to 50 minutes). Control samples were hardened in high velocity air at -28.9 C $\pm$ 1.1 C. All samples were stored at the latter temperature for varying periods of time.

After tempering the samples at -15°C for 24 hours, samples were given to expert judges for evaluation of body and texture. No body and texture differences were noted between controls and nitrogen-hardened samples. Samples stored for 6 months showed no evidence of shrinkage. Based on this study, the hardening process of ice-cream production can be speeded up drastically without damage to ice-cream quality. A proviso of economic feasibility must be made.

*Department of Agricultural Engineering.

**Mass average = two-thirds the radius from the center.

ANIMAL NUTRITION SECTION

EFFECT OF DIETARY CALCIUM AND PHOSPHORUS LEVEL ON PERFORMANCE, CARCASS CHARACTERISTICS AND BONE MINERALIZATION OF SWINE

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

Two factorial experiments involving 224 SPF Yorkshire pigs were conducted to evaluate dietary calcium and phosphorus levels in corn-soybean meal diets for pigs from 18.6 to 95.6 kg bodyweight. In experiment I, phosphorus levels of 0.50, 0.63 or 0.75% and calcium levels of 0.65 or 0.75% were fed to a mean weight of 46 kg, after which phosphorus levels were reduced to 0.4, 0.5 and 0.6% and calcium levels to 0.5 and 0.6%, respectively. An additional phosphorus level of 0.38% fed to 46 kg bodyweight followed by 0.3% was used in experiment II. Dicalcium phosphate and calcium carbonate were used to adjust dietary calcium and phosphorus levels.

No significant ($P < .05$) differences in gains, feed/gains, metacarpal ash or turbinate ash were detected among pigs fed the three higher phosphorus levels or the two calcium levels in either experiment. In experiment II, pigs fed 0.38% phosphorus gained significantly ($P < .01$) slower (683 vs 783 gm/day), required more feed per unit gain (3.46 vs 3.15) and had a lower ash content in the metacarpals (49.2 vs 52.3%) and turbinates (31.7 vs 40.6%) than those fed the three higher phosphorus levels. Carcasses of barrows fed the low phosphorus level had significantly ($P < .05$) more backfat (3.64 vs 3.44 cm) smaller l. dorsi areas (26.6 vs 29.7 cm²) and lower ham and loin percentages (36.9 vs 38.6) than those fed the three higher phosphorus levels.

Pooled gains (gm/day) feed/gains, metacarpal ash (%) and turbinate ash (%), respectively, for experiments I and II were: (0.50% phosphorus), 801, 3.20, 54.8, 40.9; (0.63% phosphorus) 791, 3.22, 54.7, 39.9; (0.75% phosphorus) 798, 3.17, 54.7, 41.0; (0.65% calcium) 786, 3.22, 54.5, 37.9; (0.75% calcium) 782, 3.26, 54.3, 38.9.

No visual symptoms of turbinate atrophy were observed in any of the pigs slaughtered.

COPPER, MOLYBDENUM AND SULFATE INTERRELATIONSHIPS IN SWINE

R. D. Kline, V. W. Hays and G. L. Cromwell

A 3 x 3 factorial experiment was used to study the effects of copper (0, 250, 500 ppm) and molybdenum (0, 50, 100 ppm) on performance of 80 pigs averaging 23.6 kg. A tenth treatment included 500 ppm copper and 200 ppm molybdenum.

Gains (kg), hemoglobin (gm/100 ml) and hematocrit (%) were depressed, but feed/gain was not influenced by feeding 500 ppm copper as compared with 250 or 0 ppm copper (0.66, 10.6, 31.8, 2.86; 0.82, 13.8, 40.2, 2.77; 0.82, 13.9, 40.7, 2.87). Similar gains, feed/gain, hemoglobin and hematocrit values resulted from feeding 0, 50 or 100 ppm molybdenum (0.78, 2.73, 12.9, 37.2; 0.76, 2.91, 12.6, 37.5; 0.76, 2.86, 13.0, 38.0). Copper levels in the liver were higher in pigs fed 500 ppm copper as compared with those fed 0 or 250 ppm copper (1,523 vs 57 and 123 ppm).

A second 3 x 3 factorial experiment was used to study the effects of molybdenum (0, 25, 50 ppm) and sulfate (750, 5,000, 10,000 ppm) in diets containing 500 ppm copper on performance of 80 pigs averaging 25.6 kg. A tenth treatment included 250 ppm copper. Gains, feed/gain, hemoglobin and hematocrit values were similar for pigs fed 0, 25 or 50 ppm molybdenum (0.62, 3.24, 11.2, 35.3; 0.61, 3.34, 11.2, 34.3; 0.61, 3.24, 11.3, 34.5) but gains, hemoglobin and hematocrit values were depressed when compared with those of

pigs fed 0 ppm molybdenum and 250 ppm copper (0.78, 14.8, 42.6). Comparable results were found in pigs fed 750, 5,000 or 10,000 ppm sulfate (0.61, 3.26, 11.2, 34.0; 0.62, 3.19, 11.5, 35.7; 0.62, 3.36, 11.0, 34.4). The effects of molybdenum and sulfate on liver copper levels were inconsistent, though 50 ppm of molybdenum tended to decrease liver copper levels.

EFFECTS OF CONTINUOUS FEEDING OF 2, 2-DICHLOROVINYL DIMETHYL PHOSPHATE (DDVP) ON PERFORMANCE OF GROWING-FINISHING PIGS

V. W. Hays, J. E. Drews and G. L. Cromwell

Sixty-four crossbred pigs averaging 23.0 kg bodyweight and 81 days old were used in an experiment to evaluate the effects of continuous feeding of DDVP (Atgard V) on growth rate, feed efficiency and internal parasitism in pigs. The pigs were penned eight per pen in pasture lots that had been used for pigs for several years though the population of pigs in the pens had been relatively low. Diets containing 18% protein were fed for 28 days after which time the level of protein was reduced to 14%. Near the end of the experiment fecal samples were collected from the pigs and soil samples from random locations in the pens were examined for ascarid and whip worm eggs. The pigs were continued on test for 66 days at which time they averaged 77.4 kg bodyweight. Levels of DDVP evaluated were 0, 50, 100 and 200 gm/ton.

Rate of gain averaged higher for those pigs receiving DDVP; however, there was no consistent trend in the response and the differences in rate of gain were not significant. Those pigs receiving the DDVP required more feed per unit of gain than the controls, but again the differences were not statistically significant. The DDVP was effective at all levels in controlling ascaris and whip worm infestation as indicated by the fecal egg counts (Table 1).

Table 1. — Effects of Continuous Feeding of DDVP on Average Daily Gain, Feed/Gain and Ascarid and Whip Worm Egg Counts in Feces

		Dietary Level of DDVP (gm/ton)			
		0	50	100	200
Average daily gain, gm					
Rep 1		822	864	808	827
Rep 2		787	820	799	839
Av		804	842	804	833
Feed/gain					
Rep 1		2.75	2.95	2.92	2.87
Rep 2		2.76	2.90	2.81	2.95
Av		2.76	2.93	2.87	2.91
Worm eggs in fecal samples (eggs per 5 gm sample)					
Rep 1	Ascaris	123	0	0	0
	Whipworm	169	0	0	0
Rep 2	Ascaris	367	0	1	8
	Whipworm	14	0	0	0
Worm eggs in soil samples ^{a/} (eggs per 50 gm sample)					
Rep 1	Ascaris	6	0	2	3
	Whipworm	0	1	0	0
Rep 2	Ascaris	0	3	0	15
	Whipworm	0	0	0	0

^{a/} Egg counts in soil samples would not be influenced by treatments applied and serve only to provide estimates of degree of contamination.

The egg counts were relatively high in the control pigs and essentially absent in the treated pigs.

Egg counts of soil samples and fecal counts of the control animals indicated that the degree of contamination was not severely high.

EFFECTS OF AUREOMYCIN AND COPPER SULFATE ON PERFORMANCE OF GROWING-FINISHING PIGS

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

One-hundred-ten Yorkshire pigs averaging 15.4 kg bodyweight and 54 days of age were assigned to 5 dietary treatments to study the effects of varying levels of aureomycin (0, 25, 50 and 100 gm/ton) and copper (250 ppm) as copper sulfate on growth rate and feed conversion. The experiment was conducted at the West Kentucky Experiment Station (Princeton) from October 1968 to February 1969.

All pigs were fed diets containing 16% protein to a pen average weight of 57 kg at which time the level of protein was reduced to 13% and continued to market weight. The pigs were housed three per pen in two replications and four per pen in four replications.

A summary of the rate of gain and feed/gain data is in Table 1. Both aureomycin and copper sulfate significantly ($P < .01$) increased rate of gain as compared with the gains of the control animals. Among the five treatments, no significant differences in feed required per unit of gain resulted.

Table 1. — Effects of Aureomycin and Copper Sulfate on Average Daily Gain and Feed Required Per Unit of Gain

Aureomycin, gm/ton	0	25	50	100	0
Copper sulfate, gm/ton	0	0	0	0	908 ^{a/}
Average daily gain, gm	786	832	854	846	831
Feed/gain	3.03	3.10	3.08	3.10	3.10

^{a/} $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ Copper level in diet, 250 ppm.

EFFECTS OF SPECTINOMYCIN ON PERFORMANCE OF GROWING-FINISHING PIGS

V. W. Hays, T. W. Keeth, C. W. Nichols and G. L. Cromwell

Two experiments involving 152 pigs were conducted to study the effects of spectinomycin (an experimental antibiotic) on performance of growing-finishing pigs. In the first experiment 72 Hampshire and Yorkshire pigs averaging 60 days of age and 14.7 kg bodyweight were assigned to six replications of three levels of spectinomycin (0, 10 and 20 gm/ton). The pigs were continued on trial until they individually reached 90 kg on weekly weighings. The average final weight was 92 kg.

A summary of the average daily gain and feed/gain data is presented in Table 1. There were no significant ($P < .05$) differences among treatments in rate of gain or feed efficiency. The antibiotic effects were inconsistent, with a trend toward improvement in rate of gain at the higher level.

In the second trial 80 Hampshire and Yorkshire pigs were assigned to five replications of four levels of spectinomycin (0, 10, 20 and 40 gm/ton). The pigs averaged 13.1 kg bodyweight and 64.9 days of age at the start of the trial, and the trial continued for 43 days at which time the pigs averaged 38 kg bodyweight.

Table 1. — Effects of Spectinomycin on Rate of Gain and Feed/Gain

Spectinomycin, Gm/Ton	0	10	20
Av daily gain, gm	694	679	744
Feed/gain	3.20	3.15	3.14

A summary of the average daily gain and feed/gain data is presented in Table 2. Supplementing the diet with spectinomycin resulted in a significant ($P < .01$) increase in rate of gain and a significant ($P < .05$) reduction in feed required per unit of gain. The pigs in the second trial were less thrifty than those in the first as evidenced by the lighter weights but older age at the start of the trial. This may partially explain the consistent response to the antibiotic in the second trial, whereas the response was inconsistent in the first trial.

Table 2. — Effects of Spectinomycin Level on Rate of Gain and Feed/Gain

	Spectinomycin, Gm/Ton			
	0	10	20	40
Av daily gain, gm	518	564	627	599
Feed/gain	2.69	2.59	2.57	2.65

EFFECTS OF CARBADOX ON THE PERFORMANCE OF GROWING-FINISHING PIGS

V. W. Hays, J. E. Drews and G. L. Cromwell

Two experiments involving 176 pigs were conducted to study the effects of carbadox (an experimental chemotherapeutic) on the performance of growing-finishing pigs. Results of previous experiments with this compound were presented in the 1967 Animal Science Research Report which referred to the compound by the code number GS-6244.

Diets containing 18% protein were fed until the pigs reached 23 kg bodyweight. The dietary protein level was reduced to 16% for the period of 23 to 57 kg bodyweight and further reduced to 14% protein for the remainder of the finishing period.

In the first trial, 80 pigs averaging 14.52 kg bodyweight and 54 days of age were assigned to four replications of five treatments. The pigs were of Hampshire and Yorkshire breeding and had been fed a high level of antibiotic in the creep and starter diet. The pigs were housed four per pen in an experimental unit that had been thoroughly cleaned and had set idle for several weeks prior to the start of the experiment. The diet treatments involved and the average daily gain and feed/gain data are presented in Table 1. No significant differences among treatments in rate of gain or efficiency of feed conversion were found.

In the second trial, 96 pigs averaging 9.62 kg bodyweight and 44.2 days old were assigned to three replications of four treatments. The pigs were Hampshire x Yorkshire crossbred pigs and were housed eight per pen. The concrete floored pens were thoroughly washed but were not disinfected and had been used for other pigs up to within a few days of the start of the experiment. The diet treatments involved, and average daily gain and feed/gain data are presented in Table 2.

Table 1. — Effects of Carbadox and Neomycin-Terramycin Combination on Rate of Gain and Feed Conversion

Body Wt, kg	Treatment No.				
	1	2	3	4	5
	Antibiotic, gm/ton				
	Control	Carbadox		Neo - Terra	
14-23	- 14	0	25	25	100 - 100
23-57	-	5	25	5	- - 20
57-68	-	5	0	5	- - 20
68-98	-	0	0	0	- - 20
Av daily gain, gm	750	748	752	756	745
Feed/gain	3.33	3.31	3.36	3.38	3.38

On the average, pigs fed carbadox gained faster and required less feed per unit of gain than those fed the control diet. The differences were, however, relatively small and were not statistically significant.

Table 2. — Effects of Carbadox on Performance of Growing-Finishing Pigs

	Carbadox Level, Gm/Ton			
	0	5	10	25
Av daily gain, gm	738	783	736	785
Feed/gain	2.95	2.95	2.89	2.88

GROWTH AND DIGESTIBILITY STUDIES WITH OPAQUE-2 AND NORMAL CORN FOR GROWING PIGS

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

Three 28-day experiments were conducted to compare the nutritive value of opaque-2 and normal corn analyzing 9.8 and 8.3% protein, and 0.35 and 0.27% lysine, respectively. Diets were supplemented with vitamins, minerals and antibiotics and each offered ad libitum to four individually-fed pigs initially averaging 13.8, 9.2 and 11.8 kg in experiments I, II and III, respectively.

In experiment I, opaque-2 corn or normal corn provided 100, 75, 50 or 25% of the total protein, with the remaining protein supplied by dehulled soybean meal (SBM). Equal parts of dextrose and starch were used to adjust the protein of all diets to 7.9%. Pigs fed the opaque-2 corn diets gained significantly ($P < .05$) faster (365 vs 279 gm/day) with less feed required per unit of gain (3.37 vs 4.78) than those fed the normal corn diets. Substitution of soybean meal protein for normal corn protein resulted in a significant ($P < .05$) linear improvement in gains (128, 191, 363 and 436 gm/day) and feed/gains (7.78, 4.93, 3.29 and 3.09). A similar response with opaque-2 corn occurred for gains (274, 363, 410 and 413 gm/day) but not feed/gains (3.78, 3.45, 3.17, and 3.06). Significant ($P < .01$) differences in apparent digestibility of opaque-2 corn and normal corn were found for dry matter (89.3 vs 87.9%), protein (68.9 vs 62.3%) ether extract (48.7 vs 54.3%) and NFE (97.2 vs 96.2%).

In experiment II, 0, 8, 16 or 24% SBM was added to opaque-2 or normal corn. Opaque-2 corn supported significantly ($P < .01$) faster (410 vs 297 gm/day) and more efficient (2.30 vs 4.69 feed/gain) gains than normal corn. SBM addition to normal corn resulted in a quadratic ($P < .05$) improvement in gains (49, 215, 465 and 458 gm/day) and feed/gains (10.95, 3.70, 2.17 and 1.96), of pigs. Gains of pigs fed opaque-2 corn were increased quadratically ($P < .05$) by SBM (240, 418, 499 and 485 gm/day) but feed conversions were not significantly ($P < .05$) influenced by SBM (3.17, 2.26, 1.88 and 1.90).

Diets in experiment III were opaque-2 corn plus 5, 10, 15, 20 or 25% SBM and normal corn plus 10, 15, 20 or 25% SBM. The effect of SBM on gains (393, 545, 557 and 606 gm/day) and feed/gains (2.38, 2.06, 1.83 and 1.78) of pigs fed normal corn was linear ($P < .01$); SBM effect on gains (379, 523, 574, 643 and 560 gm/day) and feed/gains (2.57, 2.34, 2.04, 1.79 and 1.84) of pigs fed opaque-2 corn was quadratic ($P < .05$).

EFFECTS OF DIETARY PROTEIN AND FAT ON INTRAMUSCULAR FAT AND BACKFAT THICKNESS OF SWINE

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

Four trials involving 116 pigs were conducted to study the effects of dietary protein and fat on intramuscular (l. dorsi) fat level and backfat thickness. In experiment I two protein levels (13 or 19%) and two levels (0 or 12.5%) of added fat were fed to pigs from 26 to 86 kg bodyweight. Pigs fed 19% protein had significantly ($P < .05$) less intramuscular fat (11.0 vs 17.1% of dry matter) and those fed the low-fat diet had less intramuscular fat (13.1 vs 15.0%). Neither the interaction nor the main effect of fat level was significant ($P < .05$). Backfat tended to be lower on the high-protein diet (3.20 vs 3.37 cm) and lower on the low-fat diet (3.20 vs 3.37 cm); however, the differences were not significant ($P < .05$).

In experiment II, pigs were fed 18 or 16% protein from 15 to 23 kg bodyweight, and the protein level was reduced 2 percentage units at 23 and 57 kg bodyweight. At 95 kg, pigs fed the higher protein sequence had less backfat (3.20 vs 3.45 cm) and less intramuscular fat (13.8 vs 14.9%); however, the differences were not significant ($P < .05$).

In experiment III pigs were fed a complete mixed diet containing 16% protein from 18 to 54 kg bodyweight and 13% thereafter, or they were changed to a corn and supplement free-choice system at 18, 36 or 54 kg bodyweight. Pigs fed the complete mixed diet throughout the test consumed more protein and had significantly ($P < .05$) less intramuscular fat (9.5 vs 12.2%) than those changed to free-choice. Those changed to free-choice at 54 kg tended to have less intramuscular fat than those changed to free-choice earlier; however, the differences were not significant ($P < .05$). No significant ($P < .05$) differences in backfat were observed.

In experiment IV pigs averaging 9.2 kg were fed 7.9, 11.1, 14.4 or 17.6% protein for 28 days followed by a diet containing 16% protein to 46 kg, followed by 13% protein thereafter to 95 kg. Though gains were markedly reduced by low protein during the 28-day period, no lasting effects on backfat or intramuscular fat were observed. In each of the trials, the correlation of backfat and intramuscular fat was less than 0.10.

EFFECT OF PROTEIN LEVEL ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING SWINE

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

An experiment involving 168 Yorkshire and Hampshire pigs initially averaging 23.6 kg bodyweight and 68 days of age was conducted to determine the effects of dietary protein level on rate of gain, feed efficiency and carcass characteristics. Pigs were fed corn-soybean meal diets containing 18 or 16% protein to approximately 53 kg bodyweight after

Table 1. — Effect of Protein Level on Performance and Carcass Characteristics of Growing-Finishing Swine

Av Pig Weight Protein, %	23 to 53 kg		53 to 96 kg		York- shire	Hamp- shire
	18	16	16	14		
No. pigs	84	84	56	56	96	72
Av daily gain, gm	697	691	702	696	706	677
Feed/gain ^a	3.89	3.97	3.88	3.94	4.02	3.81
Carcass data ^b						
Length, cm	76.5	77.3	76.4	78.5	77.3	76.4
Backfat, cm ^c	3.05	3.10	3.07	2.95	3.35	2.67
l. dorsi area, cm ²	30.19	29.87	31.35	29.61	28.00	32.77
Ham and loin, % of carcass	38.2	39.5	38.6	39.7	37.1	41.1
Lean cuts, % of carcass	54.9	55.2	55.0	55.7	53.4	57.3

^a The relatively high feed/gain ratios are attributed to an outbreak of transmissible gastroenteritis which occurred during the experiment.

^b Barrows only.

^c Adjusted to 92 kg bodyweight.

which they were fed diets containing 16, 14 or 12% protein to an average weight of 96 kg. Each diet was fed to four replicate pens of four Yorkshire pigs each and three replicate pens of four Hampshire pigs. Carcass data were obtained on all of the barrows.

Gains and feed/gains were improved by feeding the higher protein levels during both the growing and finishing stages although the differences were slight and non-significant (Table 1). The relatively high feed/gain ratios in this experiment were attributed to an outbreak of transmissible gastroenteritis which occurred approximately midway through the experiment.

Table 2. — Effect of Protein Level on Performance and Carcass Characteristics of Growing-Finishing Swine

Pig Weight, kg	Protein, %	
	18	16
14-23	16	14
23-68	14	12
68-92		
No. pigs	36	36
Av daily gain, gm	717	694
Feed/gain	3.12	3.21
Carcass data ^{a/}		
Length, cm	77.1	76.7
Backfat, cm	3.23	3.51
<u>l. dorsi</u> area, cm ²	27.9	29.3
Ham and loin, % of carcass	38.6	38.2

^{a/} Barrows only.

Carcasses were not markedly affected by the level of protein fed during the growing stage. Increasing the protein from 12 to 14% during the finishing stage resulted in carcasses with less backfat, larger l. dorsi areas, and greater percentages of ham and loin and lean cuts. A further increase in dietary protein from 14 to 16% did not result in a further improvement in the carcasses except for an increase in l. dorsi area.

Hampshires gained slower but required less feed per unit of gain than Yorkshires. Carcasses of Hampshire barrows were shorter but had less backfat, larger l. dorsi areas, and greater percentages of ham and loin and lean cuts than did carcasses of Yorkshire barrows.

In a second experiment, 72 Hampshire and Yorkshire pigs initially averaging 14.7 kg and 60 days of age were used to determine the effects of two protein level sequences (18-16-14% vs 16-14-12%) on performance and carcass characteristics. Dietary protein levels were reduced by 2 percentage units at an average pig weight of 23 kg and again at an average weight of 68 kg. Each diet was fed to 36 pigs, penned in 9 replicate pens of 4 pigs each. Pigs were removed from the experiment as they reached 90 kg on weekly weighings, and carcass data were obtained on the barrows.

Pigs fed the higher protein level sequence gained faster and required less feed per unit of gain than those fed the lower protein levels; however, the differences were not significant (Table 2). Carcasses of barrows fed the two protein levels were similar, though backfat tended to be lower in pigs fed the higher protein levels.

COMPARISON OF CORN AND WHEAT IN DIETS FOR GROWING-FINISHING SWINE

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

An experiment involving 27 Yorkshire pigs was conducted to determine the value of wheat as a substitute for corn in diets for growing-finishing pigs.

A 16% protein corn-soybean meal diet fortified with vitamins, minerals and antibiotics was fed to an average pig weight of 57 kg followed by a protein level of 13% to 96 kg bodyweight. In two additional diets, wheat was substituted for one-half or all of the corn. Each diet was fed to two replicate pens of four and five pigs, initially averaging 31.9 kg.

Pigs fed the corn-soybean meal diet gained faster and required less feed per unit of gain than those fed a diet containing a combination of corn and wheat or a diet containing wheat as the only cereal grain (Table 1).

Table 1. — Comparison of Corn and Wheat in Diets for Swine

Item	Diet ^{a/}		
	Corn	$\frac{1}{2}$ Corn $\frac{1}{2}$ Wheat	Wheat
Av daily gain (gm)			
Replication 1	940	913	885
Replication 2	822	804	799
Average	881	858	844
Feed/gain			
Replication 1	3.02	3.36	3.30
Replication 2	3.29	3.43	3.40
Average	3.16	3.40	3.35

^{a/} All 16% protein diets contained the following: corn and/or wheat, 75.25%; dehulled soybean meal, 21.8%; dicalcium phosphate, 1.25%; calcium carbonate, 0.75%; iodized salt, 0.50%; and trace mineral-vitamin-additive mix, 0.45%.

The data of this experiment suggest that wheat has approximately 95% of the value of corn when substituted for one-half or all of the corn in diets for growing-finishing swine.

EFFECT OF DIETARY ASCORBIC ACID ON PERFORMANCE OF GROWING-FINISHING SWINE

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

Two experiments involving 238 growing-finishing pigs were conducted to evaluate the effects of ascorbic acid supplementation of corn-soybean meal diets on performance of swine. In experiment 1, diets containing 0, 110, 220, or 440 mg ascorbic acid per kg of diet were each fed to eight replications of four pigs from a mean weight of 22.5 to 92.1 kg. Pigs fed diets with ascorbic acid gained slightly faster (733 vs 728 gm/day) and required less feed per unit of gain (3.36 vs 3.44) than those fed diets without ascorbic acid; however, the differences were not significant ($P < .05$). Mean values of pigs fed 110, 220, and 440 mg/kg ascorbic

acid, respectively, were: gain (gm/day) 733, 744, and 723; feed/gain, 3.42, 3.30, and 3.37. Serum cholesterol and serum ascorbic acid levels in pigs were not affected by dietary ascorbic acid.

In experiment II, 15 replications of three or four pigs per pen were fed diets with or without 220 mg ascorbic acid per kg of diet from 15.4 to 95.7 kg bodyweight. Pigs fed ascorbic acid gained slightly faster (836 vs 824 gm/day) but required a similar amount of feed per unit of gain (3.08 vs 3.09) as those fed a diet without ascorbic acid.

EFFECT OF EVAPORATIVE COOLING ON THE PERFORMANCE OF FINISHING SWINE

C. H. Read,*J. N. Walker*, V. W. Hays and G. L. Cromwell

The trend to confinement swine production systems has brought about the need for better environmental control. In the winter months the optimum temperature and humidity can be provided economically with ventilation and supplemental heat; however, the summer months present a serious problem. At present mechanical air-conditioning is too expensive to be used to cool market hogs. An analysis of an evaporative cooling system indicated that temperature extremes could be controlled by use of an evaporative cooling system.

In July and August 1968, four environmental systems were tested at the University of Kentucky Swine Research Center. The primary objective of this study was to determine the effectiveness of evaporative cooling for improving the rate of gain and feed efficiency of finishing hogs in central Kentucky. Test 1 utilized an experimental high-pressure spray-mist evaporative cooling system. Test 2 was a commercial wetted-pad evaporative cooling system. Test 3 was a regular fan ventilation system of the type presently used in commercial hog houses. Test 4 was an air-conditioned system to provide optimum environmental conditions; however, due to faulty equipment which caused numerous breakdowns, optimum temperatures were not maintained. Each of the first three tests were identical except for the type of cooling used. All ventilation rates were the same. Each test was replicated five times with four pigs per replicate. Average initial weight and age of the pigs were 38 kg and 95 days, respectively. The experiment was conducted for 56 days at which time the pigs averaged 83.2 kg.

Daily gains of pigs in the regular fan-ventilated test averaged 785 gm compared with 840 gm for pigs in the spray-mist evaporative cooling system and 795 gm for the pigs in the wetted-pad system. The feed required per unit of gain for pigs in the three systems was 3.37, 3.37 and 3.20, respectively. The results of the air-conditioned test were excluded because of the equipment problems.

This research project will be modified and continued during the summer of 1969.

BLUEGRASS-LADINO CLOVER AND SORGHUM-SUDAN HYBRID FOR GRAZING STEER CALVES

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

Much emphasis has been placed on sorghum-sudan forages as a summer pasture for grazing cattle. The tremendous yielding properties and rapid growth during the summer months seem advantageous, since forage production in many Kentucky pastures is low during July, August and September. This experiment was designed to compare the average daily gains of steers grazing bluegrass-ladino clover pastures with the gains of steers grazing a sorghum-sudan hybrid.

*Department of Agricultural Engineering

Fifty-two Angus steer calves were allotted to two groups using a modified block design. The steers were blocked and allotted according to origin and weight. Funks 77F sorghum-sudan was seeded on a 12.3-acre pasture at the rate of 50 lb/acre. This pasture was divided into four approximately equal plots to facilitate rotational grazing. The bluegrass-ladino pasture was an established 51-acre sod, divided into fields of 25 and 26 acres. The size of the pasture plots used in this study was such that forage would not be limiting to the steers at any time during the experiment. All steers were vaccinated for blackleg, malignant edema and hemorrhagic septicemia and implanted with 24 mg of diethylstilbestrol prior to the grazing period. The excess forage in the bluegrass-ladino pasture was controlled by clipping. The excess growth of the sorghum-sudan was controlled by limited clipping and by the addition of extra cattle to these pastures. Salt and steamed bone meal were provided *ad libitum*. Individual steer weights were taken at the beginning and end of the testing period. These individual weights were based on duplicate weights of each steer after an overnight shrink. The grazing period was from June 22 to October 6.

The steers were placed on the sorghum-sudan hybrid forage plots 25 days after seeding. A sample of plants from these plots averaged 21 inches in height. The bluegrass-ladino plots were not pastured for 24 days prior to the initiation of the study. Steers were rotated on sorghum-sudan plots an average of every 4.2 days. Steers grazing the bluegrass-ladino pastures were rotated every 21 days. The steers grazing the hybrid forage consumed 3.81 lb salt and 0.35 lb steamed bone meal per head during the experiment. Those steers grazing bluegrass-ladino pasture consumed 3.73 lb and 0.31 lb of salt and steamed bone meal, respectively. The gains of steers are presented in Table 1. The average daily gain for the steers grazing the sorghum-sudan pasture was 1.30 lb, while that for the bluegrass-ladino group was 1.29 lb. Group weights recorded at 28-day intervals throughout the experiment indicated that both groups gained similarly throughout the summer. Symptoms of prussic acid poisoning was not evident at any time when the steers were grazing the sorghum-sudan forage. These data suggest that steers make equivalent gains on bluegrass-ladino and sorghum-sudan forages when the forage availability is not limited.

Table 1. — Gains of Steers Grazing Sorghum-sudan and Bluegrass-ladino Pastures^{a/}

	Sorghum-sudan	Bluegrass-ladino
Initial weight, lb	543.9	531.2
Final weight, lb	680.3	666.6
Average daily gain, lb	1.30	1.29

^{a/} Grazing period was from June 22 to October 6.

CREEP FEEDING SPRING AND FALL CALVES

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

Providing supplemental feed for nursing beef calves is a widely used and controversial practice. The purpose of creep feeding is to correct any nutritional deficiency which the calf may have. The fact that the practice of creep feeding is controversial is not surprising in view of the many differences which exist with respect to quality and quantity of pasture, milk production of the dam, season of birth, age of the calf and use of the calf after weaning. This Station has initiated a long-term study to determine the benefits of creep feeding spring and fall calves running on either bluegrass-ladino clover or fescue-ladino clover pastures. The first two year's data with limited numbers of calves grazing bluegrass-clover pasture are summarized in Tables 1 and 2.

Table 1. — Two-year Summary for Creep Feeding Spring Calves, 1967-68

	No Creep	Creep
No. calves	25	24
Average daily gain, lb	2.01	2.10
Av creep feed per head daily, lb ^{a/}	--	3.02

^{a/} Calves were weaned at an average age of 194 days and received creep feed during the last 140 days.

Table 2. — Two-year Summary for Creep Feeding Fall Calves, 1967-68

	No Creep	Creep
No. calves	35	36
Average daily gain, lb	1.62	1.74
Av creep feed per head daily, lb ^{a/}	--	3.39

^{a/} Calves were weaned at an average age of 216 days and received creep feed during the last 154 days.

ENERGY AND PROTEIN SUPPLEMENTS FOR WINTERING YEARLING STOCKER STEERS

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

The cost of producing winter feed has stimulated interest in the use of standing dried grass for wintering cattle. Surplus summer forage has been left standing from a variety of production systems. This experiment was designed to compare the gains of yearling stocker steers grazing grass range from December through April and fed limited protein and energy.

One hundred twenty-five yearling Angus steers averaging about 665 lb and in thin flesh were blocked by weight and randomly allotted to five groups. The five treatment groups were:

1. Grass range only.
2. Grass + protein blocks (37% crude protein) free choice.
3. Grass + 1 lb soybean meal (50% crude protein)/steer/day.
4. Grass + 3 lb ground shelled corn/steer/day.
5. Grass + 1 lb SBM + 3 lb corn/steer/day.

The range grazed in this study was 341 acres of predominantly bluegrass sod. The grass had been allowed to grow up in the late summer and fall months. The range was divided into 10 pastures, and the steers were rotated among pastures weekly to insure consumption of similar forage by each group. They were offered salt and steamed bone meal free choice. Low quality grass hay was fed to all groups at the rate of 16 lb/steer daily only when the range was completely covered with snow. The steers were vaccinated for blackleg and malignant edema prior to the testing period. They were injected with 1 million IU of vitamin A on December 6 and January 31. The wintering period was from December 6 to April 24.

The gains of steers during the wintering period are summarized in Table 1. The protein blocks were fed free choice, and the steers consumed an average of 0.46 lb per steer daily. This treatment resulted in no improvement in gain over that of the steers grazing the grass range. A slight improvement in gain was observed in the group fed 1 lb soybean meal per steer daily. The group fed ground shelled corn showed an increase over the grass range and both protein supplement groups. The addition of 1 lb soybean meal to the corn group resulted in further improvement in gains. These data suggest that stocker steers can make limited gains on winter grass range with limited or no supplemental feeding. Compensatory feedlot gains, future marketing systems available, the economics of supplementation and the price spread from fall to spring must be considered in the implementation of such a wintering program. The use of more winter range for dry, pregnant cows being wintered in Kentucky is an interesting possibility.

Table 1. — Performance of Steers Wintered on Grass Range Plus Energy and Protein Supplements^{a, b/}

	Grass only	Protein ^{c/} blocks	Supplement		
			1 lb SBM	3 lb corn	1 lb SBM + 3 lb corn
No. steers	25	25	25	25	25
Initial wt, lb	667	666	667	665	663
Av daily gain, lb	0.37	0.33	0.43	0.70	0.91

^{a/} Wintering period was from December 6 to April 24.

^{b/} Each steer was fed 512 lb grass hay while the ground was snow covered (Dec. 28 to Jan. 22, Feb. 20 to 23 and Mar. 23 and 24).

^{c/} Protein blocks (37% crude protein) were fed free choice.

EFFECT OF LIMITED WATER INTAKE ON FEED CONSUMPTION AND NUTRIENT DIGESTIBILITY

P. R. Utley, N. W. Bradley and J. A. Boling

Water can easily be considered a vital part of the nutrient intake of an animal. In fact, water is required in greater amounts than is feed. It is generally considered that about two parts of water are consumed for each one part of air-dry feed depending on environmental temperature, humidity and the electrolyte balance of the animal. This experiment was conducted to study the effect of restricted water intake on voluntary feed intake, nutrient digestibility and nitrogen metabolism in cattle.

Six yearling Angus steers were offered water free choice, 80% of free choice and 60% of free choice. Water was available to the two free-choice steers at all times. The amount consumed by these steers was recorded prior to both the morning and afternoon feedings, and the appropriate percentage of this amount was offered to the water-restricted steers at these two times daily throughout the experiment. Steers and water intakes were arranged in a replicated 3 x 3 Latin square using a cross-over design. The steers were subjected to their respective treatments for a 12-day preliminary period after which quantitative fecal and urine collections were made for 7 days. A full feed of a 11% crude protein ground ear corn-urea ration was offered twice daily to each steer. During the 7-day collection periods, excreta was collected daily according to standard procedures for balance trials.

The average daily water and feed consumption of steers receiving the three levels of water are shown in Table 1. Feed intake was significantly ($r = 0.624$) correlated with water intake. As water intake was reduced to 60% of free choice, the feed intake was significantly

($P < .05$) decreased from 6.2 kg to 4.8 kg per day. When water was restricted, the water:dry matter ratios were reduced from 2.9 to 2.4 and 2.2 on water free choice, 80% of free choice and 60% of free choice, respectively. It is suggested that restriction of water intake resulted in reduced voluntary feed intake, but the decrease in dry matter intake was proportionately less than the degree of water restriction.

Table 1. — Average Daily Water and Feed Intake of Steers on Restricted and Non-restricted Watering Regimes

Item	Treatment		
	Free-choice Water	80% of Free-choice Water	60% of Free-choice Water
Water intake (l/day)	15.5 ^a /	12.4 ^b /	9.2 ^c /
Feed intake (kg/day)	6.2 ^a /	5.9 ^{a, b} /	4.8 ^b /
Water:dry matter ratio	2.9:1	2.4:1	2.2:1

^{a, b, c}/ Means on the same line bearing different superscript letters differ significantly ($P < .05$).

The apparent digestibility coefficients of the water-restricted steers were consistently higher but not significantly greater than those of the control group. There was a significant ($P < .01$) correlation for digestibilities of dry matter, nitrogen free extract and gross energy with water intake levels. It was also observed that a significant ($r = 0.738$) relationship existed between dry matter and crude protein digestibilities. In this study it was impossible to determine if the trend toward increased apparent digestibility coefficients was due to reduced water intake or reduced feed intake since both factors occurred simultaneously. However, digestibility was significantly correlated to water intake in several instances but never to feed intake.

The nitrogen balance of the six steers on each level of water intake is shown in Table 2. Nitrogen intake decreased with water restriction owing to reduced voluntary feed intake

Table 2. — Average Daily Nitrogen Consumption and Excretion and Nitrogen Retention for Water-restricted and Non-restricted Steers

Item	Treatment		
	Free-choice Water	80% of Free-choice Water	60% of Free-choice Water
<u>Intake:</u>			
N consumed (gm/day)	77.4 ^a /	73.2 ^{a, b} /	60.2 ^b /
<u>Excretion:</u>			
Fecal N (gm/day)	24.6 ^a /	21.6 ^{a, b} /	17.8 ^b /
% of total intake	34.6	29.5	29.7
Urine N (gm/day)	47.3 ^a /	44.3 ^a /	34.9 ^b /
% of total intake	62.9	60.5	57.6
<u>Retention:</u>			
Intake-excretion (gm/day)	5.4	7.3	7.5
% of total intake	5.5	10.0	12.5

^{a, b}/ Means on the same line bearing different superscript letters differ significantly ($P < .05$).

associated with water restriction. Correspondingly, total fecal nitrogen and total urinary nitrogen were also reduced. When nitrogen excretion was expressed as a percent of intake, the percentage of consumed total nitrogen excreted in the urine was significantly ($r = 0.768$) correlated to nitrogen retention. Nitrogen retention increased as urinary nitrogen excretion decreased.

Table 3 reveals a significant ($P < .05$) increase in blood urea nitrogen concentration owing to water restriction. Urine urea nitrogen excretion followed a similar pattern as total urinary nitrogen. As water was restricted, urea nitrogen excretion was reduced owing to lower nitrogen intakes. When this value was expressed as a percent of consumed nitrogen, urinary urea nitrogen excretions were increased owing to water restriction. These observed differences became even greater when urea nitrogen was expressed as a percent of urinary nitrogen excreted.

Table 3. — Blood Urea Nitrogen Concentration and Average Daily Total Urea Nitrogen Excretions in the Urine

Item	Treatment		
	Free-choice Water	80% of Free-choice Water	60% of Free-choice Water
Blood urea N (mg/100 ml) ^{c/}	7.4 ^{a/}	8.6 ^{b/}	9.3 ^{b/}
Urinary urea-N (gm/day)	29.7	28.5	27.9
% of total N intake	38.4	38.9	46.4
% of urinary N excreted	62.8 ^{a/}	64.3 ^{a/}	80.0 ^{b/}

^{a, b/} Means on the same line bearing different superscript letters differ significantly ($P < .05$).

^{c/} Composite of 2 serum samples per steer during the total excreta collection periods.

FEEDLOT PERFORMANCE OF STEERS FED TWO LEVELS OF UREA

G. D. Potter, C. O. Little, N. W. Bradley and G. E. Mitchell, Jr.

Previous reports have shown that, with the use of surgically prepared experimental animals with indicator techniques, as much as 20% less total nitrogen reached the abomasum in steers fed urea than in steers fed soybean meal. Presumably, nitrogen is lost through ruminal absorption, and less nitrogen is available for microbial synthesis in the rumen and less protein is available for digestion and absorption in the small intestine when urea is fed. This experiment was conducted to determine if increasing levels of supplemental urea might overcome the depression in feedlot performance often observed when urea replaces an isonitrogenous amount of soybean meal.

Sixty yearling steers, averaging approximately 750 lb in weight, were implanted with 24 mg diethylstilbestrol and randomly assigned to one of the ration supplements shown in Table 1. Lots of 10 steers each received ground shelled corn at a level of 8 lb and supplement at a level of 1.9 lb per head per day, and corn silage *ad libitum*. Fed in this manner, the total rations on an air-dry basis contained approximately 11% crude protein for soybean meal (SBM) and low urea, and 13.5% crude protein for the high urea rations. Trace mineralized salt and bone meal were provided free choice.

Table 1. — Ingredient Composition of Supplements Fed With Corn Silage and Ground Shelled Corn (%)

Ingredient	SBM	Supplement	
		Low Urea (percent)	High Urea
SBM, 44%	96.4	-	-
Urea, 281	-	13.1	23.0
Gd shelled corn	-	67.5	57.6
Gd corn cobs	-	14.5	14.5
Bone meal	-	0.9	0.9
Sulfur	-	0.4	0.4
Gd limestone	3.6	3.6	3.6
Vitamin A, IU/lb	10,500	10,500	10,500

The results of the 112-day feeding experiment are summarized in Table 2. Steers on all treatments were fed the same amount of corn and supplement and consumed almost the same amount of corn silage. Steers fed the urea supplement isonitrogenous with SBM gained 0.20 lb per day less and required 1.1 lb more feed than did SBM-fed steers. Feeding a higher level of supplemental urea did not improve daily gain or feed efficiency over feeding the low-urea supplement. If depression in feedlot gains with urea is related to lesser quantities of protein reaching the site of digestion and absorption as previously suggested, this condition does not appear to be alleviated by increasing the level of urea in the ration.

Table 2. — Feedlot Performance of Steers Fed Soybean Meal or Urea Supplements

	SBM	Supplement	
		Low Urea	High Urea
No. of steers	20	20	20
Initial wt, lb	751	750	750
Av daily gain, lb	2.07	1.87	1.83
Feed/lb gain ^a	11.32	12.42	12.72
Av daily intake, lb			
Corn silage	35.6	35.1	35.1
Gd shelled corn	8.0	8.0	8.0
Supplement	1.9	1.9	1.9

^a/Corn and supplement were calculated on as-fed basis and corn silage on a 90% dry matter basis.

NITROGEN SOURCES FOR FEEDLOT STEERS FED GROUND EAR CORN RATIONS

A. W. Young, N. W. Bradley, C. O. Little, J. A. Boling
and J. R. Overfield

The consistent depression in gains observed when urea replaces soybean meal as a nitrogen supplement in steer finishing rations not only suggests inefficient utilization of the urea but also raises the question as to what would be the performance when feeding no supple-

mentary nitrogen. Further, when feeding long yearling steers the requirements for protein during the latter phase of the feeding period might be met by ear corn alone. This experiment was conducted to investigate these possibilities.

One-hundred-twenty yearling Angus steers were allotted to 4 rations: I-soybean meal; II-urea; III-soybean meal the first 56 days and no supplementary nitrogen the last 56 days; IV-no supple-nitrogen the entire 112 days. All steers were fed in lots of 10, and the treatments were replicated 3 times. The composition of the rations fed is shown in Table 1. Rations were fed free-choice during the 112-day feeding period.

Table 1. — Composition of Rations Fed to Finishing Steers (112-Days)

Ingredient	Ration ^{a/}		
	SBM	Urea	No Suppl
		(percent)	
Ground ear corn	89.0	97.1	98.3
Soybean meal (44%)	9.4	--	--
Urea 281	--	1.2	--
Ground limestone	0.6	0.5	0.5
Dicalcium phosphate	--	0.2	0.2
Plain salt	1.0	1.0	1.0

^{a/}Rations supplemented with 1000 IU vitamin A per lb.

Feedlot performance and carcass data are summarized in Table 2. Gains made by steers receiving SBM either the first 56 days only or the entire 112 days were significantly greater than those of steers receiving no supplementary nitrogen. The similarity of gains made by steers fed either urea or no supplementary nitrogen suggests that urea is being utilized only to a slight extent. Soybean meal supplementation resulted in maximum performance. Further work is necessary to establish the minimum length of time SBM may be fed with no effect on performance.

Table 2. — Feedlot Performance and Carcass Data of Steers Fed Different Nitrogen Sources (112-Days)

Item	Ration			
	SBM I	Urea II	SBM-No Supp. III	No Suppl IV
No. of steers	30	30	30	30
Initial weight, lb	732	733	736	730
Final weight, lb	1004	980	1011	967
Av daily gain, lb	2.43	2.20	2.46	2.12
Av daily feed, lb	23.48	23.44	23.63	22.87
<u>Carcass Data</u>				
Dressing %	62.68	61.82	62.19	61.74
U.S.D.A. grade ^{a/}	12.4	12.2	12.0	11.7
Marbling score ^{b/}	5.3	4.8	4.9	4.5
Fat thickness, in. ^{c/}	0.51	0.44	0.53	0.45
Ribeye area, sq. in.	11.94	11.91	12.12	11.86

^{a/}11 = high good, 12 = low choice, 13 = average choice.

^{b/}4 = slight, 5 = small

^{c/}Measured at the 12th rib

LEVEL OF FEED INTAKE AND MOLASSES ADDITIONS TO UREA RATIONS FOR FEEDLOT STEERS

A. W. Young, N. W. Bradley, C. O. Little and
J. A. Boling

Previous work has shown that the addition of 2.5% blackstrap molasses to urea rations returned about one-half of the depression in gains associated with feeding urea when compared with soybean meal as the nitrogen source in finishing rations. At the same time, molasses addition to urea rations increased feed intake above that of steers fed urea rations. Three trials were conducted to compare steer performance on urea-2.5% molasses rations when their intake was limited to that of the free-choice consumption of steers on urea rations.

In each of 3 trials 20 yearling steers were individually fed a ground ear corn ration supplemented with the following: I-soybean meal (SBM), II-urea, III-urea-2.5% molasses, IV-urea-2.5% molasses. Rations I, II and III were offered free-choice during the 140-day feeding period while ration IV was fed at the level of ration II. All rations were supplemented with either SBM or urea to contain 11.0% crude protein and were isocaloric.

Results are summarized in Table 1. Steers receiving the urea ration (II) gained 0.32 lb less per day and consumed 2.21 lb less feed per day than steers fed SBM. The addition of 2.5% molasses to urea-supplemented rations returned 0.20 lb of the depression in gain, and feed consumption also increased. When consumption of the urea-2.5% molasses (IV) was limited to that of the urea ration (II), gains were still 0.17 lb greater than those made by steers on urea rations.

These results suggest that the benefits of adding molasses to urea rations for feedlot steers are not only increased feed consumption in a free-choice feeding regime but also the provision of certain factors stimulatory to rumen microorganisms.

Table 1. — Feedlot Performance of Steers Fed Soybean Meal, Urea and Urea-2.5% Molasses Free-choice and Urea-2.5% Molasses Limited to Urea Consumption

	Ration			
	I	II	III	IV
No. of steers	15	15	15	15
Initial weight, lb	658	659	672	666
Final weight, lb	977	923	961	955
Av daily gain, lb	2.20	1.88	2.08	2.05
Av daily feed consumed, lb	20.67	18.46	21.11	18.26
Feed/lb of gain	9.44	9.93	10.30	8.84

^a/Averages for three trials.

SOYBEAN MEAL AND UREA IN STEER FINISHING RATIONS

N. W. Bradley, J. R. Overfield, C. O. Little, J. A. Boling

Previous reports have indicated that steers fed rations containing the supplemental nitrogen as urea did not gain as rapidly as those fed the nitrogen supplement as soybean meal. This experiment was conducted to compare the feedlot performance of steers fed rations in

which varying proportions of the supplemental nitrogen was supplied as soybean meal and urea.

One hundred-twenty Angus steers averaging 759 lb were blocked by weight and randomly allotted to six treatment groups. Each treatment group was represented by replicated lots of 10 steers each. All groups were fed a full feed of corn silage which had 7 lb of urea-281 added per ton as the silo was filled. In addition, each steer was fed 10 lb per head daily of a grain mixture with the supplemental nitrogen supplied as follows: (1) soybean meal (SBM) (2) 3/4 SBM and 1/4 urea, (3) 1/2 SBM and 1/2 urea, (4) 1/4 SBM and 3/4 urea, (5) urea and (6) urea + molasses + alfalfa meal. The composition of each ration is presented in Table 1. The steers were fed the finishing rations for 122 days.

Table 1. — Composition of Rations Fed to Finishing Steers With Corn Silage^{a/}

	Ration					
	1	2	3	4	5	6
	SBM	3/4 SBM 1/4 urea	1/2 SBM 1/2 urea	1/4 SBM 3/4 urea	Urea	Urea +
Gr shelled corn	86.45	88.88	91.30	93.73	96.20	86.25
Soybean meal, 44%	11.35	8.50	5.70	2.85	---	---
Urea 281	---	.37	.75	1.12	1.50	1.45
Molasses, wet	---	---	---	---	---	5.00
Dicalcium phosphate	0.50	.55	.60	.70	.80	.80
Gr limestone	0.70	.70	.65	.60	.50	.50
Salt	1.00	1.00	1.00	1.00	1.00	1.00
Alfalfa meal, 17%	---	---	---	---	---	5.00
Vitamin A ^{b/}	+	+	+	+	+	+

^{a/} Each steer was fed 10 lb daily plus corn silage ad libitum.

^{b/} 4 million IU per ton

The feedlot performance is presented in Table 2. The steers consumed approximately the same amount of corn silage per head daily. The steers fed the supplemental nitrogen as SBM and 3/4 SBM + 1/4 urea had similar gains. The groups of steers fed the grain mixture supplemented with 1/2 SBM + 1/2 urea and 1/4 SBM + 3/4 urea gained similarly, but their gains were lower than those of steers fed rations 1 and 2. The gains of the group fed all of the supplemental nitrogen as urea (ration 5) with no added factors were lower than those of any other group. The addition of molasses plus alfalfa meal resulted in gains equal to those of the steers fed rations 3 and 4. The depression in gain by the group fed urea as the supplemental nitrogen source (ration 5) and partial alleviation of the depression by added factors (ration 6) are consistent with previous observations in steers fed ground ear corn rations.

Table 2. — Feedlot Performance of Steers Fed Varying Levels of Soybean Meal and Urea

	Ration					
	SBM	3/4 SBM 1/4 urea	1/2 SBM 1/2 urea	1/4 SBM 3/4 urea	Urea	Urea +
No. steers	20	20	20	20	20	20
Initial wt, lb	758	760	758	755	759	761
Corn silage/day, lb	46.6	46.3	46.1	45.6	46.2	46.1
Grain ration/day, lb	10	10	10	10	10	10
Av daily gain, lb	2.69	2.73	2.53	2.59	2.28	2.56

SOYBEAN MEAL, UREA AND NO SUPPLEMENTARY NITROGEN COMPARISONS FOR STEERS FED CORN SILAGE

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

Previous soybean meal-urea comparisons as nitrogen sources for steers being finished on corn silage and a minimum of grain had shown the consistent depression in gains observed with feeding urea in ground ear corn rations. This experiment was initiated to observe the performance of finishing steers receiving no supplemental nitrogen compared to steers either fed soybean meal or urea supplements with corn silage.

Sixty yearling Angus steers were allotted at random from 10 weight groups to 1 of 3 rations. Ration sources of supplemental nitrogen were: I-soybean meal; II-urea; III-no supplemental nitrogen. Steers were fed in lots of 10 head, and each treatment was replicated 2 times. In addition to the supplements shown in Table 1, all steers received corn silage free-choice during the 156-day feeding period.

Table 1. — Composition of Supplements for Corn Silage
Rations Fed to Finishing Steers (156-days)

Ingredient	Supplement, % ^{a/}		
	SBM	Urea	No Suppl N
		(Percent)	
Ground shelled corn	70.5	75.0	73.8
Ground cobs	--	18.3	23.6
Soybean meal (44%)	27.2	--	--
Urea 281	--	4.1	--
Ground limestone	0.2	--	--
Dicalcium phosphate	--	0.5	0.4
Plain salt	2.1	2.1	2.1

^{a/} Supplements contained 3200 IU vitamin A per lb.

Feedlot performance and carcass data for the steers receiving the different supplements are shown in Table 2. Steers fed no supplemental nitrogen gained significantly less than those receiving either SBM or urea ($P < .05$). Also, steers fed SBM as a supplement to corn silage rations gained significantly faster than those receiving urea as a nitrogen source ($P < .05$). The daily free-choice consumption of corn silage was about 2.0 lb greater for steers receiving supplementary nitrogen.

Carcass data showed that steers fed SBM as a supplement graded higher and finished earlier as evidenced by their thicker fat covering than steers receiving no supplementary nitrogen. Steers fed the urea supplement were intermediate in all carcass data.

Results of this experiment suggest that although maximum performance on corn silage rations is with soybean meal supplements urea does improve performance over no supplementary nitrogen.

Table 2. — Feedlot Performance and Carcass Data of Steers Fed Soybean Meal, Urea or No Supplemental N with Corn Silage Rations (156-days)

Item	Ration		
	SBM I	Urea II	No Suppl N III
No. of steers	20	20	20
Initial weight, lb	687	686	685
Final weight, lb	1004	937	889
Av daily gain, lb	2.03	1.61	1.31
<u>Av daily feed</u>			
Supplement, lb	8.0	8.0	8.0
Corn silage, lb ^{a/}	35.71	35.58	33.45
<u>Carcass data</u>			
Dressing %	60.93	59.49	57.44
U.S.D.A. grade ^{b/}	12.2	11.2	10.8
Marbling score ^{c/}	4.9	4.2	4.0
Fat thickness, in. ^{d/}	0.44	0.39	0.27
Ribeye area, sq in.	11.84	11.81	11.02

^{a/} Corn silage as fed.

^{b/} 11 = high good, 12 = low choice, 13 = average choice.

^{c/} 4 = slight, 5 = small.

^{d/} Measured at the 12th rib.

FEEDING BEHAVIOR OF STEERS FED SOYBEAN MEAL AND UREA SUPPLEMENTED DIETS

J. A. Boling, N. W. Bradley and D. C. Buck

Ruminal ammonia concentration is increased rather rapidly after feeding ruminants diets containing urea. The ammonia is utilized by rumen microorganisms for synthesis of microbial protein. The rate of ammonia release from non-protein nitrogen and preformed proteins influences the extent to which the ammonia is converted to microbial protein. The quantity of feed consumed at each feeding and the frequency of feeding could feasibly influence the utilization of non-protein nitrogen. This study was designed to observe the feeding patterns of steers fed diets in which the supplemental nitrogen was added as urea or soybean meal.

Ten steers were randomly allotted to two groups which were fed a ground ear corn diet supplemented with urea or soybean meal to contain 11% crude protein. The steers were fed the respective diets *ad libitum* in individual pens. Feed weighbacks were taken each day at 6:30 am, 12:30 pm and 6:30 pm for a 5-day period. In addition, the steers were observed at 5-minute intervals, and a record was made as to whether each steer was eating. This procedure was continued 24 hr/day for 5 consecutive days.

The daily feed intake of the steers fed ground ear corn diets supplemented with urea or soybean meal is summarized in Table 1. The group fed the soybean meal diet consumed 22.8 lb/day, while those fed the urea diet consumed 19.0 lb/day. The depression in feed intake by those steers fed the urea-supplemented diet is consistent with previous reports. The steers fed the soybean meal diet consumed 64.9% of their total daily intake from 6:30 am

to 6:30 pm, while the urea-supplemented group consumed 62.1% of their daily diet intake during this same time period. A summary of graphic analyses showed the patterns of eating for both groups of steers to be very similar. Increased eating was observed in each group near the times that feed weighbacks were taken.

Table 1. — Daily Feed Intake of Steers Fed Diets Supplemented with Soybean Meal and Urea^{a/}

	6:30 am- 12:30 pm	12:30 pm- 6:30 pm	6:30 pm- 6:30 am	Daily feed
Soybean meal diet, lb	6.8	8.0	8.0	22.8
% of total intake	29.8	35.1	35.1	----
Urea diet, lb	4.8	7.0	7.2	19.0
% of total intake	25.3	36.8	37.9	----

^{a/} Mean feed intake of five steers over a 5-day period per treatment group.

NITROGEN IN THE DIGESTIVE TRACT OF STEERS FED SOYBEAN MEAL OR UREA

C. O. Little, N. W. Bradley, J. A. Boling and G. E. Mitchell, Jr.

Preceding reports have indicated that feedlot performance of yearling cattle fed ground ear corn with a simple urea supplement is consistently inferior to the performance when soybean meal is used as the supplemental nitrogen source. Apparently, nitrogen utilization is a contributing factor. Previously reported work has indicated that less total nitrogen reaches the abomasum of steers fed urea than of steers fed isonitrogenous quantities of soybean meal. This experiment was conducted to observe the nitrogen concentrations in various sections of the digestive tract of feedlot steers receiving soybean meal or urea supplement.

Twelve yearling steers were individually fed ground ear corn rations supplemented with soybean meal (SBM) or urea to contain 10.5% crude protein for a 112-day feeding period. At termination of the feeding period the steers were slaughtered 3 to 4 hours after being removed from feed, and samples of contents were collected from the rumen, abomasum, duodenum, jejunum, ileum, cecum and rectum. Total nitrogen, protein nitrogen, and dry matter in the samples were determined.

The results of this experiment are summarized in Table 1. The concentrations of total nitrogen in all sections of the digestive tract exceeded the concentrations in the rations, being highest in the duodenum with SBM and highest in the jejunum with urea. Total nitrogen concentration in the rumen, abomasum, duodenum and jejunum were markedly lower in steers fed urea than in those fed SBM. Differences were small in the ileum, cecum and rectum. Protein nitrogen concentrations were consistently lower in the urea-fed steers, but a similar trend was observed among the various sections of the digestive tract. These observations lend additional evidence that quantitative differences exist in the nitrogen in the digestive tract of steers fed soybean meal or urea. These differences may provide the basis for explaining the inferior performance of feedlot cattle receiving urea supplements.

Table 1. — Nitrogen in Digestive Tract of Steers Fed Soybean Meal or Urea Supplements (gm N/100 gm DM)

	SBM		Urea	
	Total N	Prot N	Total N	Prot N
Ration	1.65	1.57	1.67	0.97
Rumen	3.08	2.13	2.22	1.45
Abomasum	2.80	1.10	1.78	0.81
Duodenum	7.36	2.59	4.90	1.92
Jejunum	6.67	2.70	5.29	1.81
Ileum	4.62	2.26	4.38	1.84
Cecum	2.39	1.74	2.21	1.54
Rectum	3.36	2.47	3.04	2.09

AMINO ACIDS IN PLASMA OF STEERS FED DIFFERENT NITROGEN SOURCES

C. O. Little, N. W. Bradley and G. E. Mitchell, Jr.

Ruminants are capable of using wide varieties of feeds; however, results of cattle feeding experiments have shown that performance may be affected by the supplement fed. Extensive efforts are directed toward providing explanations for differences in feedlot performance. Studies have indicated that quantities of certain nitrogenous compounds available for absorption can vary with different dietary nitrogen sources. Free amino acids in the blood plasma represent the dynamic portion of proteins that are available for tissue synthesis throughout the body. Plasma amino acid patterns have been suggested as indexes of the adequacy of absorbed nutrients. The work reported here was concerned with studying the plasma amino acid levels in yearling steers on finishing rations supplemented with different nitrogen sources.

One hundred thirty-two yearling steers in three experiments were fed ground ear corn rations supplemented with different nitrogen sources to provide 11% crude protein. In each ration, the supplemental nitrogen provided about 40% of the total nitrogen intake.

In experiment I, 12 steers were individually self-fed soybean meal (SBM) or urea supplemented rations. Plasma samples were collected at the initiation and 112-days of this experiment. In experiment 2, 60 steers were fed free-choice SBM, distillers dried grains with solubles (DDG/S) or corn gluten meal (CGM) supplemented rations. Plasma samples were collected after 125-day feeding period. In experiment 3, 60 steers were fed free-choice DDG/S, urea or urea + 1/2 lb molasses per day supplemented rations. Plasma samples were collected after 120-day feeding period.

The plasma amino acid levels in steers fed SBM or urea supplemented rations (experiment I) are shown in Table 1. There was a general increase in the levels from 0 to 112-days except for glycine when SBM was fed. With the urea supplemented ration, lysine and leucine remained fairly constant; however, isoleucine, valine and glycine decreased. Lysine, isoleucine, leucine, valine, glutamic acid and total levels were higher and glycine was lower with SBM than with urea at the end of the feeding period. Steers fed SBM gained 2.92 lb/day and required 7.49 lb feed/lb gain while steers fed urea gained 2.36 lb/day and required 8.44 lb feed/lb gain.

Plasma amino acid levels of steers in experiment II are summarized in Table 2. The levels were similar with SBM and DDG/S; however, valine, isoleucine, leucine, threonine,

Table 1. — Plasma Amino Acid Levels (umol/100 ml) in Steers Fed Ground Ear Corn Supplemented with SBM or Urea

	O-Day	112-Day	
		SBM	Urea
Valine	33.4	37.6	26.5
Methionine	2.4	2.6	2.5
Isoleucine	14.0	15.4	10.5
Leucine	19.6	25.7	20.2
Phenylalanine	5.8	7.1	6.3
Lysine	12.2	15.3	12.5
Histidine	6.8	11.9	11.1
Arginine	9.6	13.1	12.3
Threonine	12.3	12.7	11.7
Aspartic	0.8	1.7	1.2
Glutamic	9.4	21.3	18.7
Serine	9.4	12.4	11.9
Glycine	32.0	20.5	26.4
Alamine	24.8	33.4	31.3
Tyrosine	4.4	6.2	5.0
Proline	13.8	17.9	15.2
Total	210	255	224

Table 2. — Plasma Amino Acid Levels (umol/100 ml) in Steers Fed Ground Ear Corn Supplemented With SBM, DDG/S or CGM (125-Day)

	DDG/S	Urea	Urea + Molasses
Valine	27.1	27.1	21.2
Methionine	2.4	2.5	2.2
Isoleucine	11.6	11.1	8.8
Leucine	22.2	20.1	17.8
Phenylalanine	4.6	5.9	5.8
Lysine	15.1	14.2	13.2
Histidine	7.6	8.3	9.7
Arginine	14.5	13.8	12.3
Threonine	9.6	9.6	6.1
Aspartic	3.1	2.5	1.4
Glutamic	15.5	16.7	16.4
Serine	13.8	13.8	10.5
Glycine	18.8	18.8	22.1
Alanine	25.9	25.5	28.1
Tyrosine	6.1	6.1	5.5
Proline	18.5	14.9	15.1
Total	215	211	196

lysine and total levels were lower and glycine and histidine were higher when CGM provided the supplemental nitrogen. Average daily gain (lb) was 2.31, 2.50 and 2.0, and lb feed/lb gain was 9.30, 8.87 and 10.78 with SBM, DDG/S and CGM, respectively.

Plasma amino acid levels of steers in experiment III are summarized in Table 3. Steers fed the urea ration had lower levels of valine, isoleucine, leucine, and total acids and a higher level of glycine than steers fed DDG/S. The addition of molasses to the urea ration resulted in slight increases in valine, leucine, lysine, glutamic acid and total levels but had no effect on isoleucine or glycine. Average daily gain (lb) was 2.48, 2.20 and 2.37, and lb feed/lb gain was 10.25, 11.84 and 11.37 with DDG/S, urea and urea + molasses, respectively.

These results confirm that plasma amino acid levels in steers can be affected by sources of dietary nitrogen in finishing rations. Relation of these parameters to feedlot performance is suggested.

Table 3. — Plasma Amino Acid Levels (umol/100 ml) in Steers Fed Ground Ear Corn Supplement-
ed With DDG/S, Urea or Urea and Molasses
(120-Day)

	DDG/S	Urea	Urea + Molasses
Valine	31.1	27.4	29.0
Methionine	3.2	2.9	2.9
Isoleucine	12.7	11.0	11.0
Leucine	26.9	21.0	22.0
Phenylalanine	7.2	6.3	6.2
Lysine	13.7	13.2	14.1
Histidine	10.1	8.7	9.1
Arginine	10.3	9.7	9.1
Threonine	13.6	12.8	12.5
Aspartic	1.4	1.3	1.3
Glutamic	18.7	17.3	19.2
Serine	10.8	11.5	11.5
Glycine	23.9	26.4	26.1
Alanine	29.3	25.3	26.7
Tyrosine	7.7	6.7	6.7
Proline	18.6	18.9	19.1
Total	241	220	226

DIGESTION OF CELLULOSE INFUSED INTO THE ABOMASUM OF STEERS

R. L. Warner, G. E. Mitchell, Jr. and C. O. Little

Previous results have indicated that significant amounts of the dietary cellulose which escape digestion in the rumen are digested in the lower gastro-intestinal tract of both cattle and sheep. Results of experiments with wethers have shown rather conclusively that most of this post-ruminal digestion occurs in the cecum and colon. Data for steers have been much less conclusive concerning the roles of different sections of the post-ruminal digestive tract in cellulose digestion. This experiment was designed to provide additional information on this aspect of post-ruminal cellulose digestion in steers.

Four 280-kg steers with cannulas in the abomasum and posterior ileum were fed 2 kg twice daily of a complete mixed basal ration analyzing 10.1% cellulose when receiving cellulose infusions, and the same ration plus 0.5% chromic oxide during the control periods. Purified wood cellulose mixed in a water slurry with 10 gm of chromic oxide was administered into the abomasal fistula at levels of 0 (control), 100, 200 and 300 gm twice daily in successive 12-day periods. During the last 6 days of each period, ileal samples were taken twice daily to represent each 2-hour interval after the morning and afternoon feedings, and total feces were collected using collection bags and harness. Cellulose recoveries from the ileal samples and feces were used in calculating digestion of infused cellulose by difference.

Results of the experiment are summarized in Table 1. Although there was some indication of depressed cellulose digestion at the 600-gm per day infusion rate, differences between rates of cellulose infusion were not significant. Average apparent post-ruminal digestion was 32.8%. This is higher than previously observed for cellulose escaping ruminal digestion in steers but agrees closely with values obtained for purified cellulose infused into the abomasum of wethers. About one-third of the post-ruminal cellulose digestion appeared to occur anterior to the ileal fistula and two-thirds posterior to the fistula. Except for the 400-gm per day infusion rate, post-ileal digestion was lower than that observed for cellulose infused into the cecum of wethers. In a previous experiment with steers, more cellulose was recovered from the feces than from ileal fistulas. This was attributed to inability to obtain samples with representative cellulose and indicator composition from the ileal fistulas. Although some adjustments were made in the application of the indicator procedure, some of the same errors may have been operative in this experiment. Recovery of chromic oxide from the feces was only 86%. When this was corrected to 100%, the resulting digestion coefficients were almost identical to those obtained by total collection.

Table 1. — Post-ruminal Cellulose Digestion Anterior and Posterior to Ileal Fistulas in Steers

Cellulose infused, gm/day	Cellulose Digestion			
	Anterior to Ileal Fistula		Posterior to Ileal Fistula	
	gm/day	%	gm/day	%
200	42.4	21.2+12.1*	29.4	14.7+10.5
400	53.7	13.4+4.2	100.8	25.4+6.5
600	33.6	5.6+3.7	109.6	18.3+6.8

* + Standard errors.

RUMEN STIMULATORY PROPERTIES OF PROLINE

H. E. Amos, C. O. Little and G. E. Mitchell, Jr.

The addition of water extracts of distillers dried solubles (DDS) to suspensions of rumen bacteria has been shown to increase *in vitro* cellulose digestion. Synthetic five-carbon compounds such as proline and valeric acid, when added to *in vitro* suspensions of rumen bacteria, result in cellulose digestion comparable to that obtained with DDS, with proline being implicated as one of the factors in DDS which is responsible for the increased cellulose digestion noted in these treatments.

Tracer levels of uniformly ^{14}C -labeled proline in the presence of stimulatory levels of unlabeled proline, valeric acid or DDS extracts were used to study the metabolism of proline by rumen microorganisms. In one study 76.5% of the ^{14}C -activity initially added as free proline was recovered in δ -amino valeric acid at the end of 12 hours' fermentation;

however, at the end of 18 hours' fermentation all activity as δ -amino valeric had disappeared and 50% of the original activity was present in a steam volatile fraction with 76% of this fraction present as valeric acid. After 24 hours' fermentation 21% and 12% of the added activity was recovered in bacterial lipids and protein.

Other work comparing treatments of stimulatory levels of proline, valeric acid or DDS extract indicated a similar distribution of ^{14}C -activity in bacterial protein and the steam volatile fraction for the valeric acid and proline treatments with slightly higher level of activity in the bacterial lipids for the valeric treatment compared with the proline treatment. Only 2.8% of the initial ^{14}C -activity was recovered in bacterial protein in the DDS treatment compared with 10.8% in the proline treatment and 7.5% for the valeric treatment; however, more activity was incorporated into bacterial lipid with the DDS treatment than for either the proline or valeric acid treatment.

These results indicated that proline is first converted to δ -amino valeric acid and finally to valeric acid during cellulose digestion by rumen microorganisms and that the carbon from proline is used in synthesis of cellular components by the rumen microorganisms. Use of the free proline in this manner may account for a part of the increased cellulose digestion observed with DDS extracts.

VARIOUS PHYSICAL MEASUREMENTS AS INDICATORS OF FAT IN COWS

A. W. Young, N. W. Bradley, P. R. Utley and D. B. Laster

Most studies have shown cow weights to be highly variable. One factor associated with weight change is that of condition or fat. If some method were available whereby the weight of the cow might be adjusted for fat, some of the variation in weight as a criteria for size might be reduced. This experiment was conducted to observe which physical measure or measurements best indicate the degree of fatness in cows.

Twenty-five cows of Angus, Hereford and Shorthorn breeding were involved in this study. These were cows which were diagnosed open at the end of the breeding season. Subsequently, they were removed from the herd and placed together for wintering on bluegrass pasture and mixed hay. The following spring various physical measurements were made.

The measurements made were selected with at least two criteria in mind--that of ease of reference and an overall estimate of "patchiness" in cows. The measurements included: (1) an ultrasonic fat reading at a point 2 inches above the triceps muscle of the shoulder and (2) another reading 2 inches behind the front of the hooks in the center of the back; and these distances: (3) from the point of the shoulder to the rear tangent; (4) from the front of the hooks to the pins; (5) from the point of the shoulder to the front of the hooks; (6) from the ground to the top of the withers; (7) from hook to hook; and (8) from ground to the chest floor; and (9) the circumference of the heart girth.

All cows were slaughtered over a 5-week period. After a 24-36-hour chill period, all external trimmable fat including the kidney and pelvic fat, which remained following the removal of the viscera, was removed and weighed. This was expressed either as total fat or as a percentage of the carcass weight.

Statistical analyses showed that only three of the measures taken were significantly correlated with total trimmable fat or the trimmable fat expressed as a percent of the carcass weight. Total fat was significantly correlated with an ultrasonic fat reading taken 2 inches behind a line from hook to hook in the center of the back, width at the hooks and circumference of the heart girth. Total trimmable fat, expressed as a percent of the weight of the carcass, was significantly correlated with one of the measures taken---that of the ultrasonic reading in the center of the back.

Cow size and the influence of body fat on the expression of cow size are important, and the positive relationships between total fat and either an ultrasonic reading 2 inches behind the hooks in the center of the back, width at the hooks or circumference of the heart girth justify further study.

TURNOVER OF VITAMIN A STORES IN MATURE BEEF STEERS

C. L. Fields, G. E. Mitchell, Jr., C. O. Little and J. A. Boling

Since the relative importance of body functions influenced by vitamin A is much different in mature animals than in young growing animals, it seems reasonable to assume that the handling of vitamin A stores might be different. In previous experiments with young growing steers, a tendency for the turnover rate of vitamin A stores to decline as the steers become older and growth rate declined was observed. In the present experiment, estimates of biological halftime of vitamin A were made, using mature steers with relatively constant body weights.

Five mature Hereford steers having previously established stores of tritium-labeled vitamin A were fed alfalfa hay, free choice minerals and water plus 0.9 kg per steer per day of ground shelled corn containing sufficient vitamin A to maintain constant liver stores. Liver samples were taken by aspiration biopsy at two-week intervals throughout the 156-day experimental period. Vitamin A and tritium analyses were conducted and vitamin A turnover rate estimated from changes in specific activity of liver vitamin A (DPM per mcg Vitamin A) with time.

The mean initial liver vitamin A level was 39.7 mcg of vitamin A per gm of liver. No significant change in liver vitamin A occurred during the experimental period. The mean biological halftime of liver vitamin A was estimated to be 320 days. When compared with the 49-day half-time previously estimated for young calves fed similarly and intermediate values for growing steers, this indicates that the turnover rate of liver vitamin A stores in steers declines with age.

LIVER VITAMIN A TURNOVER IN MATURE RAMS

J. A. Boling, G. E. Mitchell, Jr., C. O. Little,
C. L. Fields and K. E. Webb, Jr.

Turnover of liver vitamin A has been demonstrated in young sheep and cattle. Little data are available on possible changes in turnover of liver vitamin A which occur during the ageing process. This experiment was designed to determine the turnover of liver vitamin A in mature rams.

Liver stores of tritium-labeled vitamin A were established in six mature crossbred rams. Each ram was intrajugularly injected with 268 uCi. of 11,12-³H-vitamin A acetate and 235,000 IU of unlabeled vitamin A acetate in 4 ml of aqueous 20% Tween 80. Throughout the experiment, the sheep were fed alfalfa hay *ad libitum* plus 680 gm cracked shelled corn per head daily. The corn was supplemented with vitamin A palmitate at a level necessary to maintain constant liver stores of vitamin A (μg vitamin A/gm liver). The rams were maintained in metabolism crates for 14 days post-injection. During this interval, total daily feces and urine were collected. Blood samples were taken by jugular puncture periodically post-injection for vitamin A and radioactivity measurements. Liver samples were taken by aspiration biopsy on day 14 and at 14-day intervals thereafter for the 140 days of the experiment.

The decline in serum vitamin A and tritium activity post-injection indicated rapid removal of the injected dose from the blood. Tritium activity of the urine (dpm/ml) was highest on day 1 post-injection and tended to stabilize after day 4 of the collection period. Fecal radioactivity (dpm/day) was greatest on day 3 and tended to remain relatively stable from day 5 to 14. The mean value of vitamin A per gm of liver did not significantly change ($P > .05$) throughout the experiment. Turnover time was calculated from changes in specific activity of liver vitamin A. The halftime of liver vitamin A was 163 ± 48 days, and turnover time was 234 ± 69 days. These times compare with a halftime of 75 days and a turnover time of 108 days reported for young ram lambs fed similarly.

INFLUENCE OF CORN OIL ON PRE-INTESTINAL DISAPPEARANCE OF VITAMIN A IN SHEEP

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

The metabolism of fat-soluble vitamins is known to be closely associated with the amount and kind of dietary fat. Moderate amounts of readily digestible fat usually enhance vitamin uptake. Excess levels of fat and poorly digested fat are usually detrimental. In addition to these general effects, high levels of unsaturated fats might enhance the destruction of a readily oxidizable vitamin such as vitamin A. With this in mind, an experiment was designed to study possible effects of dietary corn oil on the extensive pre-intestinal disappearance of vitamin A observed in sheep.

Six mature crossbred wethers with permanent abomasal cannulas were used in a simple reversal experiment. Each wether was fed 1 kg daily of a ground mixed basal ration containing cracked corn, alfalfa hay, soybean meal, molasses, dicalcium phosphate, ground limestone and salt with either 7% corn starch (control) or 7% cottonseed oil added. A 2-week preliminary period was followed by two recovery trials at 1-week intervals. Treatments were then reversed and the entire procedure repeated, yielding a total of 12 determinations for each treatment.

Pre-intestinal disappearance of vitamin A was estimated by collecting abomasal contents 24 hours after administration of 250,000 IU of vitamin A acetate and 5 gm of chromic oxide in separate gelatin capsules. The change in ratio of chromic oxide to vitamin A from the ratio administered was used to estimate the percentage of administered vitamin A reaching the abomasum.

In agreement with previous results, major portions of the administered vitamin A apparently failed to reach the abomasum. Disappearance averaged 62.1% when the control ration was fed and 69.3% when the cottonseed oil ration was fed. Since most of the apparent increase in disappearance could be attributed to low vitamin A recoveries from two wethers when they were fed cottonseed oil and recoveries from other wethers were similar on both treatments, treatment effect was not significant. It is concluded that adding cottonseed oil to the ration had little influence on pre-intestinal vitamin A disappearance.

PLASMA AND URINARY COMPONENTS IN VITAMIN A-DEFICIENT EWES

K. E. Webb, Jr., G. E. Mitchell, Jr., and C. O. Little

Polyuria accompanied by several changes in the composition of plasma and urine of vitamin A-deficient wethers and a marked preferential uptake of ^{14}C -beta-carotene by the adrenal glands of vitamin A-deficient lambs have been reported in previous "Kentucky Animal Science Research Reports." These and other reports strongly suggest a possible alteration of adrenal metabolism as a result of vitamin A deficiency. The experiments reported here were designed to determine if vitamin A-deficiency produced a similar pattern of changes in the composition of plasma and urine of ewes. Exploratory assays of hormones related to adrenal metabolism were also conducted.

Fourteen crossbred ewes were each fed 908 gm per day of a carotene-deficient ration composed of ground corn cobs, ground milo and soybean meal. Supplemental vitamin A palmitate (3122 IU/kg) was added to the ration of seven of the ewes. Over a 5 1/2-month period, four urine collection periods at 6- to 8-week intervals and from 3 to 5 days in length were made. Ewes were maintained in metabolism crates, and urine was collected by catheter into clean plastic bags. Samples were taken daily and frozen for later analysis. At the beginning of each collection period blood samples were taken by jugular puncture.

Analyses for the several key constituents of the plasma and urine, which were previously observed to be affected in wethers, revealed varied degrees of difference in these ewes.

As shown in Table 1, plasma vitamin A was significantly lower in the vitamin A-deficient group throughout all collection periods, with the severity of depletion increasing with time. Plasma urea was significantly higher in the deficient animals in all periods except the last. Significant differences were also observed in plasma phosphate, calcium and potassium during different periods of this experiment with no consistent pattern evolving. The data for these ewes are quite similar to the plasma data obtained from vitamin A-deficient wethers. The analysis of plasma for cortisol, a major adrenal hormone, showed no statistically significant difference owing to treatment at any of the four collection periods.

Table 1. — Plasma Constituents of Vitamin A-Deficient and Control Ewes

	Period 1		Period 2		Period 3		Period 4	
	Cont	Def	Cont	Def	Cont	Def	Cont	Def
Vitamin A (mcg/100ml)	29.0	17.1**	37.0	9.4**	-	-	25.7	7.5**
Urea (mg/100ml)	29.7	46.7**	16.1	18.4**	19.3	22.9*	18.0	20.2
Phosphate (mg/100ml)	7.0	5.7	7.2	6.9	6.6	7.3	5.1	6.4*
Calcium (mg/100ml)	11.1	9.4*	10.0	9.9	10.2	10.2	10.6	10.3
Sodium (meq/L)	156.2	155.7	157.0	152.5	160.9	156.4	146.4	151.4
Potassium (meq/L)	5.3	4.8	5.5	5.7	5.2	5.7**	5.0	5.2
Cortisol (mcg/100ml)	65.2	69.8	59.7	57.2	68.0	64.7	54.8	57.7

(Cont = control; Def = deficient)

* Significantly different from controls, $P < .05$

** Significantly different from controls, $P < .01$

Results of urine analyses are presented in Table 2. Vitamin A-deficient ewes produced significantly more urine of a significantly lower osmolality than did control ewes. This polyuria is consistent with previous observations on wethers. The significant differences observed in urea and sodium excretion were not consistent with time and varied somewhat from the pattern observed with wethers. The pattern of urea excretion by these ewes was similar to that observed with wethers. However, sodium excretion was significantly reduced by a lack of vitamin A in wethers, while a significant increase was observed in ewes during period 2. No effect on phosphate excretion was observed.

The vitamin A-deficient ewes had considerably higher mean daily excretions of phosphate but the difference was not statistically significant. A similar elevated phosphate excretion was significant in wethers. Calcium and potassium excretion and urinary pH were not affected by treatment. Likewise, the use of 17-ketogenic steroid and cortisol excretion as possible indicators of adrenal metabolism revealed no significant effect of vitamin A deficiency.

The data collected in this study show that a deficiency of vitamin A in ewes produces several changes in the composition of plasma and the excretion of various components via the urine, some of which are similar to those previously observed with wethers. Whether these differences are due to sex still remains to be answered. The lack of a significant effect on cortisol or 17-ketogenic steroid excretion does not confirm the hypothesis that adrenal metabolism may be altered. These broad indicators may lack the specificity necessary to measure altered adrenal metabolism. Studies employing more sensitive measures of adrenal metabolism are in progress.

Table 2. — Analyses on Urine of Vitamin A-Deficient and Control Ewes

	Period 1		Period 2		Period 3		Period 4	
	Cont	Def	Cont	Def	Cont	Def	Cont	Def
Volume (ml/day)	697	900*	740	1,194*	543	844**	832	1,180
Osmolality (mOsm/kg)	1,403	1,045**	1,397	873**	1,904	1,216**	1,327	872*
Urea (gm/day)	5.0	6.3*	8.6	8.0	9.8	9.3	8.8	8.3
Sodium (gm/day)	3.6	3.0	2.0	2.5*	2.1	2.2	1.5	1.6
Phosphate (mg/day)	263	331	316	694	338	565	90	406
Calcium (mg/day)	1.4	3.5	4.1	2.5	1.3	1.5	4.1	2.7
Potassium (gm/day)	5.0	5.3	4.8	5.4	6.1	6.1	4.9	5.4
pH	6.4	5.9	5.4	5.5	6.4	6.2	5.4	5.6
17-Ketogenic Steroids (mg/day)	12.4	15.2	11.7	13.6	12.2	11.5	12.5	13.9
Cortisol (mcg/day)	297	284	377	354	364	354	445	327

(Cont = control; Def = deficient)

* Significantly different from controls, $P < .05$ ** Significantly different from controls, $P < .01$

AMYLASE ACTIVITY IN THE PANCREATIC SECRETIONS OF SHEEP FOLLOWING GLUCOSE INFUSIONS

J. L. Call, G. E. Mitchell, Jr., C. O. Little and J. A. Boling

Experiments utilizing both fistulated steers and wethers have shown that large amounts of non-fermented starch may pass from the rumen when large quantities of grain are fed. This unfermented starch is available for digestion by amylase in the small intestine and/or by microbial action in the cecum and colon. Owing to the low levels of amylase produced by the pancreas of ruminants, the potential for intestinal amylase digestion is inherently low. However, results of previous studies have indicated that the level of amylase secreted by the pancreas increases as the level of dietary starch increases. Similar responses have been shown in rats. The mechanism by which this response is mediated has not been well established, but the blood glucose levels have been implicated as serving a major role in this adaptative response in monogastric animals. The purpose of this experiment was to study the influence of blood glucose elevations on the amylase activity of the pancreatic secretions of wethers.

Mature wethers were fitted with re-entrant cannulas of the common bile duct in a manner designed to allow collection of the secretions of the pancreas. These cannulated wethers were used in a two-phase experiment. In phase one the total flow of bile and pancreatic secretions was collected from five animals. The secretions were collected in 10-minute fractions for 30 minutes. A single dose of glucose solution was then injected intravenously to investigate the influence of transient blood glucose elevations on pancreatic amylase activity. The collection was continued for another 50 minutes. In phase two samples of pancreatic secretions were taken to investigate the influence of prolonged periods of blood glucose elevations on the production of pancreatic amylase. The levels of blood glucose were elevated by the infusion of various glucose levels for two 3-hour periods each day for from 3 to 7 days.

The single injections of glucose did not influence the amylase activity of the proteins secreted by the pancreas. The prolonged periods of glucose infusion resulted in a depression of the specific amylase activity of the pancreatic proteins. The specific amylase activity was depressed 44% following a glucose increase of 95 mg per 100 ml of plasma and 42%

following a plasma glucose increase of 37 mg per 100 ml of plasma. In another animal a glucose increase of 29 mg per 100 ml of plasma resulted in an 18% decrease in specific amylase activity, but a glucose elevation of 14 mg per 100 ml of plasma caused no detectable depression in the specific amylase activity of the secreted protein.

Failure of amylase secretion to respond to single injections of glucose indicates that glucose does not act as a releasing factor for pancreatic amylase. The dramatic decrease in amylase secretion following prolonged major increases in blood glucose suggests either a direct or an indirect effect of blood glucose on pancreatic amylase secretion. While glucose levels lower than those tested might have an opposite effect, failure to obtain any response at the lowest level tested and the direction of response to the higher levels of glucose both make it seem improbable that glucose is a primary factor in the increased pancreatic amylase output resulting from increased grain intake in ruminants.

DIGESTION OF CELLULOSE INFUSED INTO THE CECUM OF LAMBS

R. L. Warner, G. E. Mitchell, Jr. and C. O. Little

Results of previous experiments indicated that about one-third of the purified cellulose infused into abomasal fistulas of wethers was digested. If this digestion resulted primarily from microbial action in the cecum and colon, similar digestion of cellulose infused into the cecum would be expected. This experiment was conducted to test that hypothesis.

Five wethers with permanent abomasal cannulas were used in 3 trials resulting in 13 estimates of the digestion of infused cellulose. Each wether was fed 450 gm twice daily of a ration containing 60% cracked corn, 18% soybean meal, 13% cottonseed hulls, 7% molasses and minerals (12.2% cellulose). Cellulose excretion during 6-day collection periods was determined with and without 30 gm of purified wood cellulose infused into the cecum twice daily.

Average daily digestion of infused cellulose was 19.6 ± 3.6 gm per day (32.7%). This corresponds closely with values obtained in previous experiments with abomasal infusion, indicating again that significant post-ruminal cellulose digestion is possible and that most of the post-ruminal cellulose digestion in sheep occurs in the cecum and large intestine.

DIGESTION OF CELLULOSE AND MIXTURES OF CORN OIL AND CELLULOSE INFUSED INTO THE CECUM OF WETHERS

R. L. Warner, G. E. Mitchell, Jr., C. O. Little and D. G. Ely

High levels of fat in the ration have been widely reported to reduce cellulose digestion in both sheep and cattle. This effect has been generally attributed to action in the rumen. If the cellulose digestion in the cecum and colon is similar to that in the rumen, fat might also influence post-ruminal cellulose digestion. Two experiments were conducted to evaluate the effect of corn oil on post-ruminal cellulose digestion in wethers. The experiments also provided observations of post-ruminal digestion of corn oil.

In experiment one, five wethers with abomasal fistulas were infused with either 30 gm of purified wood cellulose or 30 gm of cellulose plus 36 gm of corn oil into the abomasum twice daily during 2-week preliminary and 6-day collection periods. In the second experiment, four cecal fistulated wethers were used in a Latin square design in which 0, 10, 20 or 30 gm of corn oil was infused with 40 gm of cellulose into the cecum twice daily. In both experiments, 450 gm of a ration containing cracked corn, soybean meal, cottonseed hulls, molasses and minerals and analyzing 12.2% cellulose was fed twice daily.

In experiment one, the apparent digestion of infused cellulose was 31.6% when infused alone and 27.2% when infused with corn oil. The difference was not significant. Apparent digestion of infused corn oil was 56.6%.

Results of experiment two are summarized in Table 1. Average cellulose digestion was lower than that observed after abomasal infusion in experiment one but was not consistently affected by corn oil. Apparent digestion of corn oil infused into the cecum was also lower than that observed after abomasal infusion but was substantial and tended to increase with level of infusion.

Table 1. — Digestion of Cellulose and Corn Oil Administered into the Cecum of Wethers

Corn oil infused, gm/day	0	20	40	60
Cellulose infused, gm/day	80	80	80	80
Infused cellulose digested, %	23.9 $\pm$ 7.9*	13.6 $\pm$ 2.4	26.2 $\pm$ 9.5	34.0 $\pm$ 12.5
Infused corn oil digested, %	—	34.5 $\pm$ 12.9	44.4 $\pm$ 10.6	49.0 $\pm$ 8.9

* $\pm$ standard errors

ORAL AND ABOMASAL ADMINISTRATION OF LYSINE TO WETHERS

R. A. Scott, C. L. Streeter, C. O. Little and G. E. Mitchell, Jr.

There is little evidence to indicate that the absorption of amino acids or the tissue requirements for amino acids differ for ruminants from that established for non-ruminants. Only by providing for absorption those amino acids which cannot be synthesized by the animal tissue can the nutritional needs be met. An imbalance in the essential amino acids absorbed would influence the protein nutrition of the animal and performance conceivably could be improved by correcting the imbalance. This study was conducted to determine nitrogen utilization in wethers receiving supplemental lysine by oral or abomasal administration.

A ration of 75 gm zein, 600 gm wheat straw, 267 gm ground corn and 42 gm dried molasses was fed in equal portions twice daily in all experiments.

The objective of the first experiment was to measure the effect of feeding a ration containing zein supplemented with lysine on the quantity of nitrogen reaching the abomasum of wethers. Four mature crossbred wethers with permanent abomasal fistulas were used in a switchback arrangement of control and 4.3 gm lysine per day was given orally. Abomasal contents were samples for 6 days following a 7-day preliminary period, and blood samples were collected on the final day. Molar percent lysine in abomasal contents, total m.mol. lysine reaching the abomasum per day (estimated by Cr_2O_3 ratios) and molar percent lysine in plasma, respectively, with control and supplemented rations were: 3.2, 67 and 3.7; 3.4, 66 and 4.1.

The objective of the second experiment was to determine if nitrogen balance of wethers could be influenced by oral supplementation of lysine to a ration containing zein. Six growing crossbred wethers were used in the experiment. The design of the experiment was a switch-back, with three of the six wethers receiving the supplemental lysine ration in one 14-day period and the non-supplemented ration in the other 14-day period. Nitrogen retention for the control treatment was 5.2 gm/day compared with 4.8 gm/day with lysine supplementation.

In the third experiment, four mature wethers with abomasal fistulas were used in a switchback design in which 4.3 gm of lysine per day was fed or infused continuously into the abomasum. Nitrogen retention during a 7-day collection period for the animals fed lysine was 3.4 gm/day and 3.7 gm/day for those receiving lysine in the abomasum. Molar percent plasma lysine increased from 3.3 when lysine was fed to 7.7 with abomasal administration.

AMINO ACIDS IN PLASMA OF EARLY WEANED LAMBS

S. E. Poe, D. G. Ely and G. E. Mitchell, Jr.

Lambs and calves are non-functioning ruminants at birth. These animals require dietary sources of high quality protein, B-vitamins and simple carbohydrates. Increasing age corresponds to increasing dry feed consumption, and dry feed consumption parallels the transformation from essentially a non-ruminant status into a functioning ruminant. Research has shown that as the rumen develops blood glucose levels decrease and volatile fatty acid concentrations increase. Other research indicates that plasma amino acid patterns may be altered by feeding different nitrogen sources to mature ruminants. The objective of the current study was to determine the changes in plasma amino acids that occur in lambs from birth to 16 weeks when fed different rations prior to weaning at 28 days of age.

Thirty crossbred ewe lambs were randomly assigned to three pre-weaning treatments of 10 lambs each at birth. In the first pre-weaning treatment (I), lambs received milk only. In treatment II, lambs received milk plus concentrate creep fed free-choice which contained 90% ground shelled corn and 10% soybean meal. Treatment III was milk plus roughage creep fed free-choice. The roughage creep contained 93% ground alfalfa hay and 7% liquid molasses. All lambs were weaned at 28 days of age.

Pre-weaning average daily gains were greater for both creep-fed groups. Post-weaning average daily gain, when all lambs were fed the same ration, favored the use of the roughage creep pre-weaning. This difference was most pronounced during the first 14 days after weaning. Concentrations of all amino acids decreased 36% from birth to 4 weeks of age and an additional 15% at 16 weeks of age. Essential amino acids remained relatively stable from 5 to 15 weeks of age, while the concentration of nonessential amino acids gradually declined during this period. Upon weaning at 28 days, the essential amino acids decreased significantly up to 3 days post-weaning with no significant changes found for the nonessentials. Consumption of milk alone pre-weaning resulted in slightly greater concentrations of essential amino acids at weaning than when a roughage creep or concentrate creep plus milk was fed. Decreases in essential amino acid concentrations immediately after weaning indicate that milk may be the primary dietary factor governing plasma amino acid levels in lambs weaned at 28 days of age.

GRASS HAYS FOR PREGNANT AND LACTATING EWES

G. L. M. Chappell, W. C. Templeton, Jr. and W. P. Deweese

Although high quality legumes are used to advantage as a basic feed for pregnant and lactating ewes, these forages are not always available in adequate amounts to meet the producer's needs. This experiment was designed to evaluate certain grass hays as roughages for gestating and lactating ewes.

Sixty-one mature crossbred ewes were randomly assigned to four feeding regimes. Sixteen ewes received shelled corn and alfalfa hay as described in Table 1. Fifteen ewes each received orchard grass, Ky 31 fescue and Kenwell fescue hays as shown in the same table. All groups received salt, ground limestone and steamed bone meal free-choice. Lambs were allowed access to a creep of 89% cracked corn, 10% soybean meal pellets and 1% antibiotic crumbles and were weaned at an average of 63 days of age.

Results are summarized in Table 1. The survival rates and lamb performance data to weaning indicate that, when properly supplemented, grass hays such as these could be utilized as a portion of wintering ration for pregnant and lactating ewes.

Table 1. — Grass Hay Evaluation

Ewes/group	16	15	15	15
Hay	Alfalfa	Orchard grass	Ky 31 Fescue	Kenwell Fescue
Daily ration				
Late gestation				
Sh corn	1 1/2 lb	1 1/2 lb	1 1/2 lb	1 1/2 lb
Hay	2 1/2 lb	2 1/2 lb	2 1/2 lb	2 1/2 lb
Early lactation				
Sh corn	1 1/2 lb	1 1/2 lb	1 1/2 lb	1 1/2 lb
Hay	3 lb	3 lb	3 lb	3 lb
Ewe wt, lb, 12/12	188.4	180.7	179.6	183.5
1/6	206.3	190.9	201.2	200.8
3/3	166.9	152.1	171.7	167.2
Wt loss	39.4	37.8	29.5	33.6
Lambing data				
Lambing percent	194	166	160	140
Survival rate, %	87	84	88	91
Lamb birth wt, lb	9.5	9.4	9.7	10.4
Lamb performance				
ADG to weaning	0.52	0.46	0.45	0.50
Creep feed/lb gain	1.07	1.13	1.29	1.14

ROUGHAGE LEVELS IN RATIONS FOR EARLY-WEANED LAMBS

G. L. M. Chappell and W. P. Deweese

Although high levels of roughage have been used successfully in complete rations for early-weaned as well as older lambs, such bulky feedstuffs are expensive to transport and somewhat difficult to process. This experiment was conducted to determine the optimum level of roughage (alfalfa meal) in rations for lambs weaned at 18 kg.

Twenty-four black-faced crossbred ewe lambs were randomly allotted to the three rations shown in Table 1. Eight lambs were individually fed each of the rations for a 54-day feeding period. The rations were ground through a 1/4" screen and pelleted in 3/16" pellets.

The results of the experiment are shown in Table 1. Lambs receiving 37.4% or no alfalfa meal in their ration tended to gain faster than lambs receiving 75% alfalfa meal; however, the effect was not significant. Each addition of corn to the ration reduced daily feed consumption and pounds of feed required per pound of gain. The performance of lambs on the ration containing no roughage indicates the possible use of all-concentrate rations for such lambs.

Table 1. — Ration Composition and Lamb Performance on Rations Containing Three Levels of Roughage

Lambs/treatment	8	8	8
Ration components (%)			
Dehydrated alfalfa meal	75.0	37.4	
Shelled yellow corn	19.0	46.4	73.7
Soybean meal (44%)		9.2	18.3
Molasses	5.0	5.0	5.0
Trace mineralized salt	1.0	1.0	1.0
Ground limestone		1.0	1.0
Lamb performance			
Average daily gain, kg	0.21	0.31	0.30
Average daily feed intake, kg	1.38	1.26	1.04
Feed/gain	5.15	4.08	3.46

FACTORS AFFECTING RUMEN MICROBIAL ACTIVITY IN YOUNG LAMBS

S. E. Poe, D. G. Ely and G. E. Mitchell, Jr.

Previously reported results have indicated that when lambs were provided a creep from birth, they had developed by 14 days of age the ability to digest starch and cellulose *in vitro* similar to the mature lamb. The objective of this study was to measure quantitatively the microbial activity of young lambs.

Thirty-two Hampshire-sired crossbred lambs were housed in individual lambing pens with their dams. At 3 days of age they were randomly allotted into 4 groups. Each group was fed as follows: (I) milk only; (II) milk plus creep; (III) milk plus pasture and (IV) milk plus pasture plus creep. Group I was housed in a galvanized pen on an asphalt floor to prevent the consumption of bedding. Group II was confined to a galvanized pen bedded with tobacco stems. Both groups I and II were allowed to nurse their dams from 5 pm to 8 am and from 12 noon until 1 pm daily. Group III and IV were confined to bluegrass pastures with their dams. Rumen samples were taken at 3, 6, 10, 14 and 21 days of age.

Tables 1 and 2 show the feed consumption and weight gains of the confined lambs and pasture lambs, respectively. The confined creep lambs, having consumed a total of 4.56 kg of the creep, gained considerably faster than lambs receiving milk only during the first 21 days of life. Providing a creep did not improve gains of lambs while they were nursing their dams on early spring bluegrass pasture during the first 21 days as shown in Table 2.

Table 3 shows the *in vitro* starch digestion by rumen microorganisms in lambs during the first 21 days of life. The confined milk-fed lambs remained low in percentage digestion of starch by rumen microorganisms *in vitro* except at the 14- and 21-day measurement periods. It was noted at these periods the milk-fed lambs were consuming some of their own feces. By 6 days of age the confined creep-fed lambs showed marked increases in percentage digestion of starch *in vitro*. Both pasture groups showed higher percentages of starch digestion than the confined milk group.

The percentage digestion of cellulose *in vitro* is shown in Table 4. The same trends occurred in cellulose digestion as were noted with starch.

These observations indicate that development of rumen function, as measured by *in vitro* starch and cellulose digestion, is closely related to the ingestion of solid feedstuffs.

Table 1. — Feed Consumption and Weight Gains of Confined Lambs, kg

Age in Days	Treatment					
	Milk			Creep		
	Creep Consumed	Gain ^{a/}	ADG	Creep Consumed ^{a/}	Gain ^{a/}	ADG
1 - 3	-	-	-	0	-	-
4 - 6	-	23	0.48	0.02	25	0.52
7 - 10	-	-	-	0.37	-	-
11 - 14	-	11	0.17	0.75	23	0.35
15 - 21	-	5	0.09	3.42	13	0.22
Total	-	39	-	4.56	61	-
Mean ADG	-	-	0.23	-	-	0.35

^{a/} Total for 8 lambs each period.

Table 2. — Feed Consumption and Weight Gains of Pasture Lambs, kg

Age in Days	Treatment					
	Milk			Creep		
	Creep Consumed	Gain ^{a/}	ADG	Creep Consumed ^{a/}	Gain ^{a/}	ADG
1 - 3	-	-	-	0	-	-
4 - 6	-	25	0.52	0.03	26	0.55
7 - 10	-	-	-	0.11	-	-
11 - 14	-	24	0.37	0.27	25	0.38
15 - 21	-	20	0.36	1.01	15	0.27
Total	-	69	-	1.42	66	-
Mean ADG	-	-	0.41	-	-	0.39

^{a/} Total for 8 lambs each period.

Table 3. — In Vitro Starch Digestion by Rumen Microorganisms in Lambs^{a/}

Age in Days	Confined		Pasture	
	Milk	Creep	Milk	Creep
3	7	7	7	7
6	9	31	12	15
10	7	31	19	16
14	14	33	14	26
21	12	33	17	23

^{a/} Represents 8 lambs sampled for each measurement.

Table 4. — In Vitro Cellulose Digestion by
Rumen Microorganisms in
Lambs^{a/}, %

Age in Days	Confined		Pasture	
	Milk	Creep	Milk	Creep
3	2	2	4	4
6	2	17	13	6
10	1	28	21	19
14	19	27	23	17
21	14	35	26	22

^{a/}Represents 8 lambs sampled for each measurement.

UREA OR HEATED SOYBEAN MEAL FOR YOUNG LAMBS

D. G. Ely, W. P. Deweese, S. E. Poe, and C. O. Little

Thirty crossbred lambs weaned at approximately 17 kg were randomly assigned to 3 rations of 10 each with 2 replications per ration. Nitrogen sources fed were urea, heated soybean meal, (HSBM) or one-half urea and one-half heated soybean meal. All rations contained 12% crude protein and were self-fed for 96 days or until lambs reached 45.5 kg. Solvent-extracted soybean was heated for 4 hours at 149°C in a forced-air oven to reduce solubility from 72 to 35%. Composition of rations are shown in Table 1.

Table 1. — Composition of Rations, %

Nitrogen Source	Urea	HSBM ^{a/}	Urea-HSBM ^{a/}
Ingredient			
Ground wheat straw	10.00	10.00	10.00
Ground alfalfa hay	10.00	10.00	10.00
Ground shelled corn	68.70	60.00	64.90
Soybean meal (44% CP)	--	10.00	4.35
Urea 281	1.30	--	0.75
Cane molasses	8.00	8.00	8.00
Steamed bone meal	1.00	1.00	1.00
Trace mineralized salt	1.00	1.00	1.00

^{a/}Heated soybean meal.

Lamb performance is summarized in Table 2.

Lamb gains were identical with all three rations (0.22 kg). No differences in daily feed intake were found between rations. Consequently, no differences were found in feed efficiency for lambs fed urea, HSBM, or one-half urea and one-half HSBM as the primary nitrogen sources. It appears that urea can be fed efficiently to lambs weaned at approximately 17 kg when fed at rates of 1.3% or 0.75% of the total ration.

Table 2. — Performance of Young Lambs Fed Urea on Heated Soybean Meal

Nitrogen Source	Urea	HSBM ^{a/}	Urea-HSBM ^{a/}
Initial weight, kg	16.5	17.3	18.0
Final weight, kg	37.2	38.6	38.8
Average daily gain, kg	0.22	0.22	0.22
Daily feed intake, kg	1.37	1.36	1.36
Feed/gain	6.23	6.18	6.18

^{a/} Heated soybean meal.

UREA FOR LAMBS FROM BIRTH TO MARKET

D. G. Ely, W. P. Deweese, S. E. Poe, and G. E. Mitchell, Jr.

Previous research has indicated that ruminal starch and cellulose digestive activity in lambs 10-14 days of age is very nearly the same as that found in the 16-week-old lamb. Therefore, it would appear that 10- to 14-day old lambs should be capable of utilizing non-protein nitrogen sources, such as urea. This study was initiated to compare performance of lambs fed urea during both pre-weaning and post-weaning phases of growth.

Thirty Hampshire-sired crossbred lambs were randomly allotted at 3 days of age to 3 pre-weaning rations of 10 lambs each. Pre-weaning ration treatments were milk only, milk plus soybean meal creep (SBM), and milk plus urea creep. Soybean meal and urea creeps contained 18.8% crude protein. The urea creep contained 1.0% by weight of the total ration. Composition of the pre-weaning rations is shown in Table 1. Lamb weights and creep feed consumption were taken weekly until lambs were weaned at 59 days of age. Each ewe received a daily ration of 0.5 kg alfalfa hay, 4.1 kg corn silage, and 0.5 kg shelled corn. At weaning the three groups of lambs were placed on the same self-fed urea ration for 98 days. This ration contained 12% crude protein and contained 1.3% urea by weight of the entire ration. Composition of the post-weaning ration is shown in Table 2.

Table 1. — Composition of Pre-weaning Creep Rations

Ingredient	SBM ^{a/}	Urea
	(percent)	
Ground shelled corn	32.6	39.3
Dehydrated alfalfa meal	20.0	20.0
Soybean meal (44% CP)	22.0	14.3
Urea 281	--	1.0
Dried whey	15.0	15.0
Sucrose	2.5	2.5
Cane molasses	5.0	5.0
Dicalcium phosphate	1.0	1.0
Trace mineralized salt	0.4	0.4
Ground limestone	0.5	0.5
Vitamin premix	1.0	1.0

^{a/} Soybean meal creep.

Table 2. — Composition of Post-weaning Urea Ration

Ingredient	%
Ground wheat straw	10.0
Ground alfalfa hay	10.0
Ground shelled corn	68.7
Urea 281	1.3
Cane molasses	8.0
Steamed bone meal	1.0
Trace mineralized salt	1.0

Results of the pre-weaning and post-weaning feeding periods are summarized in Table 3. Pre-weaning gains favored both SBM and urea creep-fed lambs over those receiving milk only. Performance of SBM-fed lambs was slightly superior to the performance of lambs fed the urea creep.

Table 3. — Pre-weaning and Post-weaning Performance of Lambs Fed Urea

Pre-weaning Treatment	Milk	SBM	Urea
Pre-weaning performance:			
Initial weight, kg	4.40	4.60	4.91
Weaning weight, kg	13.71	19.14	18.60
Average daily gain, kg	0.163	0.260	0.245
Daily feed intake, kg	--	0.20	0.19
Feed/gain	--	0.75	0.77
Post-weaning performance ^{a/} :			
Initial weight, kg	13.71	19.14	18.60
Final weight, kg	35.53	42.98	43.09
Average daily gain, kg	0.220	0.252	0.254
Daily feed intake, kg	1.10	1.44	1.69
Feed/gain	5.00	5.72	6.65

^{a/} At weaning lambs fed different pre-weaning rations were placed on the same urea ration shown in Table 2.

Lambs that received creep feed prior to weaning gained faster post-weaning than those receiving milk only pre-weaning. Lambs that received milk only prior to weaning were the most efficient of the three groups after weaning. However, this was probably because these lambs were smaller as indicated by the 6 to 8 kg differences in initial and final post-weaning weights. Lambs fed SBM prior to weaning were slightly more efficient in feed conversion after weaning than the group fed the urea creep pre-weaning. This difference was a result of the difference in daily feed consumption between the SBM and urea groups.

AMINO ACIDS IN EQUINE CECAL CONTENTS, CECAL BACTERIA AND SERUM

C. M. Reitnour, G. E. Mitchell, Jr.,
J. P. Baker and C. O. Little

Protein utilization in all species depends on the amino acids available to the tissues. Differences in amino acid composition of the content of the digestive tract from that of the feed consumed can be in part explained by the addition of endogenous proteins and to microbial activity. It has been suggested that plasma amino acids could be used as indicators of adequacy of protein nutrition in non-ruminant species with portal blood a more sensitive indicator than peripheral. This study was conducted to compare the amino acids in feed with those in cecal contents, cecal bacteria and serum from ponies fed three common grain diets.

Three crossbred ponies with permanent cecal fistulae were fed three ground, pelleted rations during 10-day preliminary and 6-day collection periods. The rations fed are shown in Table 1. Rations and ponies were arranged in a 3 X 3 Latin square replicated in time. Cecal content samples were taken once each 12-hour period at 2, 4, 6, 8, 10 and 12 hours after both morning and afternoon feedings, composited over time for each pony, then frozen until analyzed. On the day following the conclusion of each collection period, serum from jugular blood samples taken prior to the morning feeding and at 2-hour intervals for 10 hours was frozen for analysis. During one trial samples of cecal bacteria were obtained at 4, 8, and 12 hours after feeding. The rations, cecal contents and cecal bacteria were subjected to hydrolysis prior to amino acid analysis. Free amino acid content of the serum samples was determined following precipitation of the proteins.

Table 1. — Composition of Experimental Diets

Ingredient	Percent		
Oats	59.8	---	---
Corn	---	89.8	---
Barley	---	---	69.2
Starch	33.1	---	22.7
Solka floc	5.5	8.7	6.6
Ground limestone	1.0	1.0	1.0
Trace mineralized salt	0.5	0.5	0.5
Vitamin A ^a	+	+	+
Chemical analysis			
Crude protein	7.2	7.4	6.7
Crude fiber	8.3	6.2	7.4

^a/ Vitamin A added at 3,000 IU/kg feed.

The total amino acid contents of the rations, cecal contents and the cecal bacteria and the free amino acid content of the serum are shown in Table 2. It was observed that cecal contents contained higher molar percentages of several amino acids than the rations. The low enzymatic digestibility of corn protein is reflected in the higher amino acid content of cecal contents than of the corn ration. With a few exceptions, the observed amino acid concentrations were consistent with the partial conversion of feed nitrogen to bacterial protein. Except for three amino acids, leucine, phenylalanine and arginine, molar percentages of amino acids in the cecal contents and serum did not appear to be closely related.

Table 2. — Amino Acid Contents of Rations and in Cecal Contents, Cecal Bacteria and Blood Serum from Ponies Fed These Rations

Ration	Total Amino Acid Concentration			Total Free Amino Acids Blood Serum
	Rations	Cecal Contents (umol/mg. of protein)	Cecal Bacteria	
Corn	9.47	11.68	8.22	4.00
Oats	10.35	7.55	8.11	4.15
Barley	9.52	7.37	8.84	3.89
Mean	9.78	8.87	8.39	4.01

Calculation of regression coefficients revealed significant regressions of serum amino acids on ration amino acids, thus suggesting the importance of enzymatic protein digestion and absorption of amino acids from the small intestine.

Additional work is needed in this area to provide a more precise separation of ileal and cecal digestive functions and to obtain portal rather than peripheral blood data.

HEPATIC UTILIZATION OF GLUCOSE AND VOLATILE FATTY ACIDS IN THE EQUINE

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

Horses and ruminants often subsist on similar types of feedstuffs, but because of anatomical differences, the processes of digestion and absorption differ considerably in the two species. In the horse the ingesta are subjected to fermentation in the cecum and colon after passing through the stomach and small intestine where the more soluble dietary components have been subjected to enzymatic digestive and absorptive processes.

Enzymatic digestion of carbohydrates results largely in the production of glucose, while microbial fermentation yields volatile fatty acids (VFAs), primarily acetic, propionic and butyric. Although the absorption of both glucose and VFAs has been demonstrated in the horse, little is known about their metabolism, and the relative importance of the different sources of energy for this species has not been determined.

The purpose of this study was to investigate hepatic utilization of energy sources in the equine through the measurement of portal-carotid differences following infusions of the substances into the cecum.

Three cecal fistulated ponies with indwelling catheters located in the portal vein and carotid artery were used. The ponies were maintained individually in box stalls with oats fed twice daily and timothy hay *ad libitum*. The treatments consisted of 250 ml of solutions (Table 1) infused into the ceca of the ponies. Blood samples were drawn from the portal and carotid catheters at 0, 15, 30 and 60 minutes following the infusions.

The plasma levels of glucose and of VFAs observed are shown in Table 2. Results from these limited data indicate that the equine liver does utilize acetate, propionate and butyrate as well as glucose. It may be noted that the comparatively low level of infused glucose had no influence upon plasma glucose levels, but it did appear to influence plasma VFA levels. The treatment solutions appeared to exert the greatest influence on portal levels at the 30-minute post-infusion collection.

Table 1. — Composition of Solutions Infused into the Cecum (amounts per 250 ml)

Treatment	Solution
Control	Water only
Glucose	6 gm glucose + water
VFA	20.9 gm Na Acetate 6.8 gm Na Propionate + water ^{a/} 3.7 ml butyric acid

^{a/} VFA solution adjusted to basic pH with NaOH.

Table 2. — Mean Levels of Glucose and VFAs Observed in Portal and Carotid Plasma

Treatment		Portal	Carotid
Control	Glucose	104.8 mg %	85.0 mg %
	Acetate	3.01 umol/ml	3.04 umol/ml
	Propionate	0.23 umol/ml	0.08 umol/ml
	Butyrate	0.06 umol/ml	0.04 umol/ml
Glucose	Glucose	90.8 umol/ml	88.7 mg %
	Acetate	3.65 umol/ml	3.06 umol/ml
	Propionate	0.38 umol/ml	0.08 umol/ml
	Butyrate	0.12 umol/ml	0.05 umol/ml
VFAs	Glucose	111.0 mg %	98.9 mg %
	Acetate	4.28 umol/ml	3.69 umol/ml
	Propionate	0.35 umol/ml	0.11 umol/ml
	Butyrate	0.22 umol/ml	0.07 umol/ml

LIQUID SUPPLEMENTS FOR LACTATING DAIRY COWS

J. S. Mudd and H. H. Van Horn

Use of liquid ingredients and supplements is not new, but new applications and practices have brought an intensified interest in recent years. The renewed interest in liquid supplements have developed because of the usability of products and by-products from industrial production by ruminants.

Experiment I

Eighteen milking Holstein cows were divided into three experimental pens for use in a 3 x 3 Latin square design. Each cow was offered daily 10.4 kg of 14% pelleted concentrate and 22.7 kg of corn silage on a group feeding basis. In addition, the control group received 0.9 kg of soybean meal (Treatment I), and the other groups received 0.9 kg (Treatment II) and 1.8 kg (Treatment III) of liquid supplement (50% crude protein, all from NPN) per cow

daily. Milk yield, silage, concentrate and crude protein intake; and body weight gain for the 63-day experimental period (kg/day) for treatments I, II, and III were, respectively: 22.5, 22.2, 20.8; 15.9, 16.2, 14.5; 10.4, 10.4, 10.4; 2.6, 2.7, 3.0; 0.53, 0.44, 0.36. Treatment III cows yielded significantly ($P < .05$) less milk. Treatment III cows also ate less silage. Blood urea (mg N/100 ml), nitrogen balance (% of consumed nitrogen) and milk fat (%) for treatments I, II and III were respectively: 16.0, 16.5, 18.5; +27, +23, +37; 2.3, 2.2, 2.1. Significant differences occurred in blood urea ($P < .05$) and nitrogen balance ($P < .10$). Milk fat depression occurred in all treatments.

Experiment 2

Twelve high-producing Holstein cows were selected and gradually shifted over a 2-week period to a ration in which corn silage was the only forage. These cows were maintained on this ration for one week at which time they were paired and divided into two groups on the basis of age and level of milk production. Cows received feed on a group basis. One group received daily 38.1 kg of a complete ration that was 71.5% corn silage, 23.8% of a 14.0% crude protein pelleted herd concentrate containing 1.0% urea, and 4.7% of soybean meal. The high-urea group received daily 39.0 kg of a complete ration that was 69.9% corn silage, 25.5% of a concentrate containing ground shelled corn and 1.5% urea, and 4.6% of liquid supplement. The high-urea treatment resulted in an intake of 423 gm of urea intake per cow daily. These rations were fed to the two groups of cows in a 2 x 2 Latin square design. Four-week periods were employed, with treatment effects evaluated on the basis of the fourth week of the period.

Feed intake was not affected in this experiment where the liquid supplement was mixed with the silage and concentrate in a complete ration. The level of liquid supplement was comparable to the 1.8 kg level of liquid supplement in Experiment 1. Milk production was significantly depressed ($P < .10$) on the high-urea treatment that included liquid supplement. This demonstrated that feeding urea as the only nitrogen supplement (423 gm/cow daily) in a ration of corn silage, shelled corn and mineral supplements was not as satisfactory for milk production as a low level of urea.

Experiment 3

Twenty-four lactating Holstein cows were divided into 6 experimental pens for use in a replicated, 3 x 3 Latin square design (3 pens per replica) with 5 weeks per period. The 3 treatments were complete rations composed of (A) 76.7% corn silage (wet weight basis), 18.6% gr. shelled corn, 4.0% soybean meal, 0.7% mineral and vitamin supplements; (B) 76.7% corn silage, 21.2% ground shelled corn, 1.0% soybean meal, 0.37% urea, 0.7% mineral and vitamin supplements; (C) 76.7% corn silage, 20.2% ground shelled corn, 1.0% soybean meal, 2.1% liquid supplement (50% crude protein, all NPN). Average milk yield and feed intake (kg/day), and milk fat percent for the final week of each period for treatments A, B and C were, respectively: 18.5, 17.6, 16.8; 38.6, 36.8, 36.2; 3.53, 3.72, 3.71. Milk yield and feed intake were depressed in the NPN rations ($P < .05$), but differences between treatments B and C were not significant. FCM differences were not significant, nor were milk fat percentages.

Conclusions

Liquid supplement (50% crude protein) seems quite satisfactory for lactating dairy cows at a level of 0.9 kg/cow daily and also at higher levels if mixed with the ration so feed intake is not reduced. Experiment 3 indicates that a liquid supplement as a source of NPN and dry urea are similar in their ability to support milk production. Therefore, liquid supplements would be advised over dry sources of NPN only if more convenient or if cost is an advantage.

SYNTHESIS AND PHYSIOLOGICAL REQUIREMENTS OF AMINO ACID FOR LACTATING COWS

Don R. Jacobson, W. A. Tucker, and R. H. Hatton

Eight mature lactating Jersey cows averaging 374 kg body weight were placed on a twice replicated 4 X 4 Latin square design balanced for milk production among treatments. All treatments included 50% of the energy from corn silage and 50% of the energy from concentrate 1 through 4 as follows: (1) ground corn; (2) 99% ground corn and 1% urea; (3) 98% ground corn and 2% urea and (4) ground corn and soybean meal isonitrogenous with concentrate No. 3. The cows were on each treatments 28 days. Digestibility and nitrogen balance data were collected the last 5 days, and plasma and rumen samples were taken the 28th day of each period. Milk production and voluntary feed intake were based on the third week of each 28-day period.

For the four treatments, in order, 4% FCM yield was 11.66, 12.25, 11.88 and 13.64 kg/cow/day; voluntary feed intake was 11.10, 10.92, 10.70 and 11.87 kg/cow/day; rumen ammonia was 9, 16, 18 and 25 ug/ml; blood plasma ammonia and urea respectively were 4, 4, 5 and 5 ug/ml and 4, 5, 7 and 6 mgm/100 ml; digestibility of nitrogen was 52, 57, 60 and 58 and energy was 64, 66, 68 and 68.

DEVELOPMENT OF METHODS FOR RELATING FORAGE PROPERTIES TO INTAKE AND DIGESTIBILITY

Don R. Jacobson, C. J. Sniffen and R. H. Hatton

Four Holstein male calves (47 to 84 kg BW) were employed in eight experiments to measure absorption of certain nutrients from the gastro-intestinal tract. Each experiment was intended to give blood flow as relative velocity at 5-minute intervals and portal-carotid concentration differences for each nutrient at 0700, 0800, 0900, 1000, 1200, 1500, 1900, 2000, 2100, 2200, 2400, 0300, and again at 0700 hours. The animals were fed at 0730 and 1930 hours.

In one calf fed 3.63 kg milk and later 0.28 kg hay and 0.82 kg starter/day, absorption respectively in mg/day/kg BW of: glucose was 1,578 and -471; total sugars was 4,243 and -603; total ketones was 1,697 and 868; and for the following amino acids was: Aspartic acid, 77, 57; Threonine 199, 18; Serine 140, -105; Proline 200, 54; Glutamic acid -7, -44; Glycine 66, 18; Alanine 137, 36; Valine 160, 11; Methionine 63, 4; Isoleucine 161, 19; Leucine 250, 46; Tyrosine 116, 30; Phenylalanine 154, 37; Lysine 211, 14; Histidine 63, 13; Arginine 133, 43 and Ammonia 23, -3. Only 18% as much amino acid was absorbed from the dry feed as was from the milk diet.

BIOASSAY, ISOLATION, IDENTIFICATION OF TOXIC FACTOR(S) IN TALL FESCUE AND VASOACTIVE MYCOTOXINS ASSOCIATED WITH TALL FESCUE

Don R. Jacobson and Suh-Jen Yau

Different fractionation schemes for 80% ethanol crude extract and dried PTT hay were described. Biological activities of these extracts were tested on laboratory animals. Tail discoloration is found to be inducible by the aqueous phase of chloroform fractionation, or dialyzed water extracts of the toxic Ky. 31 fescue. The unknown vaso-active substance is found to be water extractable, non-volatile, heat stable and dialyzable. Biological activities of PTT and orchard hay were compared, and the results indicate that they have similar

properties, though the PTT hay has a stronger tendency of causing vasodilation. Violet discoloration and lesions on tails are induced in laboratory animals with deficiency of essential fatty acids by long-term administration, under low environmental temperature, of the PTT hay. Analysis of the polyunsaturated acids in heart samples indicates that essential fatty acids deficient diet alone causes decrease in contents of dienoic, and tetraenoic acids, and increase in that of trienoic acid. Intake of the PTT hay has the effect of reducing both the contents of dienoic and trienoic acids.

GENETICS AND PHYSIOLOGY SECTION

SYNCHRONIZATION OF ESTRUS OF GILTS WITH AIMAX, PMS AND HCG

G. L. Cromwell, V. W. Hays, R. H. Dutt and T. W. Cathey

Two experiments were conducted to evaluate the efficacy of methallibure (AIMAX) pregnant mare serum (PMS) and human chorionic gonadotrophin (HCG) as a means of synchronizing estrus in gilts. Eighty-seven Hampshire, Yorkshire and Hampshire-Yorkshire crossbred gilts were used in the study. All gilts were approximately 8 months old at time of mating.

In experiment I, AIMAX was mixed in the feed and fed to 48 gilts for 20 days at a rate of 125 mg/gilt/day. Following withdrawal of AIMAX from the feed, 43 (90%) of the gilts exhibited estrus (Table 1). Of the 43 gilts, 38 (87%) exhibited estrus 6 to 9 days following withdrawal of the estrus drug. Most of the gilts were given 2 natural services at 24-hour intervals beginning at the onset of estrus. The farrowing rate (percent farrowed of those bred) was 91%. The length of the gestation period was quite variable, with a range of 112 to 120 days and an average of 115.1 days. Hampshire gilts tended to have shorter gestation periods than Yorkshires or Crossbreds.

In experiment II, 24 gilts were each given 125 mg of AIMAX daily in their feed for 20 days. Twelve of these gilts were injected with 1000 IU of PMS on day 21, 500 IU of HCG on day 25, and inseminated with fresh extended semen on day 26. The remaining 12 gilts and 15 control gilts were mated naturally at 24-hour intervals after onset of estrus. All gilts given PMS and HCG exhibited estrus 6 days after withdrawal of AIMAX from the feed (Table 2). The average number of days to estrus after AIMAX withdrawal in gilts not given PMS and HCG was 7.3 days, with a range of 6 to 9 days.

Table 1. — Estrus Synchronization of Gilts with AIMAX^{a/}

Item	Yorkshire	Hampshire	Crossbred	Total
No. gilts	24	16	8	48
Following AIMAX withdrawal,				
No. showing estrus on:				
day 6	8	1	1	10
day 7	4	8	2	14
day 8	4	4	2	10
day 9	3	1	-	4
days 10-21	3	-	2	5
Total No. showing estrus	22	14	7	43
Av days to estrus ^{b/}	7.1	7.4	7.2	7.2
No. farrowed	21	12	6	38
Farrowing rate, %	95	86	86	91
Length of gestation				
range, days	113-120	112-117	114-117	112-120
average, days	115.7	114.0	115.2	115.1

^{a/} Fed at a rate of 125 mg/gilt/day for 20 days.

^{b/} Average of those showing estrus on days 6 to 9 following drug withdrawal.

Table 2. — Estrus Synchronization of Gilts with AIMAX, PMS and HCG

AIMAX, days fed ^{a/}	---	20	20
PMS, injected ^{b/}	---	---	day 21
HCG, injected ^{b/}	---	---	day 25
Mated	Natural	Natural	day 26
No. gilts	15	12	12
Following AIMAX withdrawal, No. showing estrus on:			
day 6	--	1	12
day 7	--	7	--
day 8	--	3	--
day 9	--	1	--
Total No. showing estrus	15	12	12
Av days to estrus	--	7.3	6.0
No. farrowed	13	10	7 ^{c/}
Farrowing rate, %	87	83	58
Length of gestation			
range, days	111-117	113-118	112-117
average, days	115.2	115.4	114.4
Total pigs farrowed	9.5	9.8	8.3
Live pigs farrowed	8.8	8.9	6.9

^{a/} AIMAX fed at rate of 125 mg/sow/day.

^{b/} 1000 IU PMS injected subcutaneous; 500 IU HCG injected intra-muscular.

^{c/} Five of six gilts mated with semen from a Yorkshire boar conceived, whereas only 2 of 6 gilts mated with semen from a Hampshire boar conceived, which suggests that semen quality may have been a factor.

The farrowing rate and litter size were lower for the gilts given the PMS and HCG and artificially inseminated. However, five of six gilts mated with semen from a Yorkshire boar conceived, whereas two of six gilts mated with semen from a Hampshire boar conceived, which suggests that the quality of the Hampshire semen may have been partially responsible for the lower conception rate.

Although the time of mating was effectively controlled by the combination of AIMAX, PMS and HCG, the farrowing dates of the gilts extended over a 5-day period because of the variation in the length of gestation. As in experiment I, Yorkshire gilts tended to have longer gestation periods than Hampshire gilts (116 vs. 114.3 days).

EFFECT OF 2, 2-DICHLOROVINYL DIMETHYL PHOSPHATE (DDVP) ON REPRODUCTIVE PERFORMANCE OF SWINE

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

Field studies have indicated that the feeding of DDVP (0.8 gm/sow/day) will reduce the number of pigs born dead and result in larger litters of live pigs at birth and weaning. One hundred sows, 34 at the West Kentucky Substation (Princeton) and 66 at the University Research Center, were divided into two groups according to breed and age of sows. Of the 100 sows, 36 were Hampshire and 64 were Yorkshire. One group served as controls, and

the other group was fed 0.8 gm of DDVP per day for a minimum period of 21 days prior to farrowing. All sows were fed 6 lb of feed per day during the treatment period and full-fed a standard lactation diet following farrowing.

A summary of the results is presented in Table 1. There was considerable variation among groups in their reproductive response, but there was essentially no evidence that DDVP, at the rate of 0.8 gm per sow per day, reduced the number of pigs dead at birth or the number dying during the first 21 days following farrowing. The average number weaned per litter was higher (8.3 vs 8.1) for the sows on the control treatment. The number of pigs born per litter and number weaned are extremely variable and observations on small groups of sows can often be misleading.

Table 1. — Effects of DDVP on Reproductive Performance of Swine

Treatment	No. Sows	Pigs/Litter At Farrowing			Birth Wt, lb	Pigs/Litter at 21 Days	No. Died	Av
		Total	Live	Dead				21-day
								Wt, lb
Control								
Hamp - U. K.	17	9.6	8.9	0.7	3.54	7.9	1.0	12.7
York - U. K.	15	9.5	9.1	0.4	3.66	8.4	0.7	12.9
York - U. K.	16	11.6	10.0	1.6	2.72	8.5	1.5	12.2
Av.		10.2	9.3	0.9	3.30	8.3	1.1	12.6
Treated (0.8 gm DDVP/day)								
Hamp - U. K.	19	9.2	8.2	1.0	3.32	6.5	1.7	11.3
York - U. K.	15	10.6	10.2	0.4	3.49	9.1	1.1	11.4
York - U. K.	18	12.0	10.8	1.2	2.67	8.6	2.2	11.6
Average		10.6	9.7	0.9	3.16	8.1	1.7	11.4

WHEN SHOULD DAIRY HEIFERS BE BRED FOR FIRST AND SECOND CALVES?

Durward Olds and A. L. Yates

Many dairymen do not breed Holstein heifers until they are 18 months old and weigh more than 750 lb. However, Cornell data show that medium-fed heifers reach puberty at about 12 months and at a weight of about 600 lb. Such heifers could be bred if so desired. Each month that they remain open means another month before they calve and come into lactation. As shown in Table 1, these days open may be added to the first calving interval and divided into total milk for the first lactation in order to determine average milk per day (Table 1). The results indicate that even though 305-day milk production increases as age of conception increases, the average production per day declines. The increases in 305-day milk owing to age at conception are most appreciable from 12 months of age to 16 months and for those bred to calve in the least desirable season (Nov.-June). A delay of one month can frequently be justified if it results in calving during a more favorable season. Perhaps two months could be justified if the heifer would still be bred at 16 months of age or less. On the average, each day that a heifer is bred younger, down to 12 months of age, results in 30 cents more annual income.

A study of 101 Holstein heifers in the Kentucky Agricultural Experiment Station herd indicated that each month of additional age at calving resulted in about 9 lb more body weight and, this in turn, resulted in 3 lb more milk. However, the effect of age, independent from body weight, was negative. Consequently, in this herd there appeared to be considerable justification for the early breeding of heifers.

Table 1. — The Effect of Age at Conception in Holstein Heifers on 305-Day Milk Production During First Lactations and Milk Per Day From Puberty to Second Calving

Conception at	Days Open Beyond Puberty	Days From Puberty to 2nd Calf ^{a/}	Nov. -June 305-Day Milk	Lb/day	July-Oct. 305-Day Milk	Lb/day
12 mo.	0	396	8,000 lbs	20.2	8,824 lbs	22.3
13	30	426	8,333	19.6	9,023	21.2
14	60	456	8,696	19.1	9,231	20.2
15	90	486	9,023	18.6	9,375	19.3
16	120	516	9,231	17.9	9,449	18.3
17	120	546	9,302	17.0	9,600	17.6
18	180	576	9,375	16.3	9,677	16.8
19	210	606	9,449	15.6	9,677	16.0
20	240	636	9,524	15.0	9,756	15.3
21	270	666	9,600	14.4	9,756	14.6
22	300	696	9,600	13.8	9,836	14.1

^{a/} Assuming an interval of 396 days between first and second calves.

^{b/} Based on USDA age of calving adjustment factors (DHI Letter, Feb. 1967).

North Carolina workers have recommended that first-calf heifers be left open for 121 days after their first calves. However, data from our own herd indicate that even though each day open results in more total milk for the current lactation, more body weight at second calving, and slightly more milk during the second lactation, these gains are not enough to make the delay economical. Reducing the number of day open by 30 would result in about 550 lb less total milk, but the average per day of the calving interval would be increased by about 1.1 lb. It thus appears that short calving intervals are desirable, even for first-calf heifers.

MOLECULAR, IONIC, AND CELLULAR MIGRATIONS IN FREEZING SOLUTIONS AND THEIR EFFECTS ON SPERM SURVIVAL

John W. McGaugh and Durward Olds

When charcoal, Rose Bengal, or washed sperm were mixed in distilled water and frozen slowly (100 minutes for 40 ml samples) there was a marked concentration of the additives near the center of the ice as observed by visual inspection. In simple salt or glycerol solutions, there was also a tendency for central concentration of the solutes at slow freezing rates as evidenced by freezing point depression and electrical conductivity of fractional samples. In yolk-citrate-glycerol solutions, sperm cells remained uniformly distributed in the ice. However, glycerol tended to concentrate in the center and helped to prevent a similar concentration, of the salts. The osmotic pressure in central portions was not high enough to show an immediate effect on sperm survival.

These studies were carried out in an effort to reveal the cause of death to about 30% of the sperm during semen freezing. While ionic migration may be a factor, it appears more likely that physical pressure between ice crystals may account for the freezing damage to sperm.

EFFECT OF SIRE ON CERTAIN CARCASS TRAITS OF YOUNG BULLS

F. A. Thrift, J. D. Kemp, N. W. Bradley and W. P. Garrigus

Data collected on the carcasses of 59 Hereford bulls slaughtered after completion of a 160-day postweaning feeding test in 1967 were analyzed to estimate the effect of sire on certain carcass traits. These 59 bulls averaged 400 days of age at slaughter and were the progeny of 8 sires (7.2 bulls/sire). Carcass data were collected 48 hours after slaughter. A 9-10-11th rib section was obtained from the left side of each carcass and dissected into fat, lean and bone. The 6-7-8th portion of the rib was roasted to 160°F and evaluated for flavor, juiciness, tenderness and overall satisfaction by a palatability panel. The longissimus muscle from the 12th rib portion was analyzed for water, protein and ether extract.

The means and standard deviations for the traits studied are presented in Table 1.

Table 1. — Means and Standard Deviations for Carcass Traits of Young Bulls

Trait	Mean	S.D.
Routine traits:		
Slaughter wt, lb	795.0	69.2
Hot carcass wt	482.0	46.1
Cold carcass wt	470.0	45.0
Carcass wt/day/age	1.2	0.1
Dressing %	59.1	1.8
Carcass conformation ^{a/}	16.0	1.1
Marbling score ^{b/}	4.0	0.5
USDA grade ^{c/}	10.0	0.9
Fat thickness, 12th rib	0.3	0.1
% kidney and pelvic fat	2.0	0.4
Ribeye area (REA)	10.7	1.1
REA/100 lb carcass	2.3	0.0
Cutability %	52.3	0.9
9-10-11th rib traits:		
Fat color score ^{d/}	2.0	0.3
Lean color score ^{e/}	6.0	1.4
% fat in rib	27.7	3.7
% ribeye in rib	18.6	1.5
% other lean in rib	35.4	2.5
% total lean in rib	54.0	3.0
% bone in rib	17.8	1.7
% water in lean	75.1	1.0
% protein in lean	20.0	0.9
% ether extract in lean	1.8	0.9
Flavor ^{f/}	6.3	0.7
Juiciness ^{f/}	6.9	0.6
Tenderness ^{f/}	6.5	0.6
Overall satisfaction ^{f/}	6.5	0.7

^{a/} 16 = Av Prime
^{b/} 4 = Slight
^{c/} 10 = Av Good (Based on steer standards)
^{d/} 2 = Creamy white

^{e/} Muncell color paddle score; 1 = very light, 9 = very dark.
^{f/} Evaluated by taste panel on a 9-point hedonic scale; 1 = dislike extremely, 9 = like extremely.

Each trait was analyzed, using a model that took into account the effect of sire. Among and within sire mean squares were equated to expected mean squares and variance components estimated. These variance components for the various traits are presented in Table 2.

Table 2. — Among and Within Sire Variance Components for Carcass Traits of Young Bulls

Trait	Variance Components ^{a/}			
	Among Sires ^{b/}	%	Within Sires	%
	(7)		(51)	
Routine traits:				
Slaughter wt, lb	490.0	9.3	4,789.1	90.7
Hot carcass wt	177.8	7.7	2,129.2	92.3
Cold carcass wt	170.3	7.8	2,027.3	92.2
Carcass wt/day/age	0.001	10.0	0.009	90.0
Dressing %	0.172	4.9	3.321	95.1
Carcass conformation	0.282	19.0	1.206	81.0
Marbling score	0.084	22.1	0.296	77.9
USDA grade	0.007	8.0	0.889	92.0
Fat thickness, 12th rib	-0.000			
% kidney and pelvic fat	0.008	5.8	0.130	94.2
Ribeye area (REA)	0.041	3.2	1.260	96.8
REA/100 lb carcass	-0.001	0.0	0.046	100.0
Cutability %	-0.054	0.0	0.795	100.0
9-10-11th rib traits:				
Fat color score	0.000	0.0	0.079	100.0
Lean color score	-0.137	0.0	1.963	100.0
% fat in rib	0.259	1.8	13.765	98.2
% ribeye in rib	-0.059	0.0	2.394	100.0
% other lean in rib	0.063	1.0	6.015	99.0
% total lean in rib	-0.591	0.0	9.096	100.0
% bone in rib	-0.029	0.0	2.744	100.0
% water in lean	-0.022	0.0	0.923	100.0
% protein in lean	0.065	7.9	0.762	92.1
% ether extract in lean	0.134	14.0	0.822	86.0
Flavor	0.005	1.0	0.501	99.0
Juiciness	0.035	9.8	0.321	90.2
Tenderness	-0.012	0.0	0.388	100.0
Overall satisfaction	0.008	1.9	0.421	98.1

^{a/} Numbers in parenthesis represent degrees of freedom.

^{b/} Negative variance components were assumed to be estimating zero.

Of the 27 traits, 9 of the sire variance components were negative, and these were assumed to be estimating zero. These results are probably due in part to sampling error, since only a small number of sires are represented.

EFFECT OF SIRE, SEX AND SIRE X SEX INTERACTIONS ON BEEF CATTLE PERFORMANCE AND CARCASS TRAITS

F. A. Thrift, D. D. Kratzer, N. W. Bradley, J. D. Kemp and
W. P. Garrigus

Purpose of this study was to estimate the effect of sire, sex and sire x sex interactions on certain performance and carcass traits in beef cattle. The data utilized were collected in cooperation with a commercial Hereford farm located near Lexington. Eight Hereford bulls were each exposed during the early spring of 1966 to 27 to 30 grade Hereford cows. The breeding groups were established by randomly allotting 227 cows on a within age-of-dam basis to 8 different groups. The sires were then randomly allotted to these 8 groups.

From 119 calves weaned, 80 were selected as a representative sample to be placed on a postweaning feeding test to evaluate differences among the 8 sires with respect to certain performance and carcass traits. The 8 sires were each represented by 10 calves, with both steers and heifers included for each sire. The average weaning age for these 80 calves was 191 days. The weaning weights were adjusted to a 200-day basis by utilizing the preweaning average daily gain, and the 200-day weights were adjusted for age-of-dam.

The number of offspring for each sire and sex classification is presented in Table 1.

Table 1. — Number of Offspring by Sire and Sex Classification

Sex	Sire								Total
	1	2	3	4	5	6	7	8	
Steers	4	4	2	4	5	6	5	4	34
Heifers	6	6	8	5	5	4	5	5	44
Total	10	10	10	9	10	10	10	9	78

Two of the 8 sires were each represented by only 9 calves. At the end of the postweaning feeding period upon slaughter, two of the male calves were found to still have one testicle retained owing to improper castration. All performance and carcass data collected on those two calves were excluded from this study.

After weaning, the calves were placed on a postweaning feeding test and received a full-feed of corn silage plus 1.4 kg of shelled corn and 0.34 kg of soybean meal per head per day. The postweaning feeding period was continued for 348 days, at which time the 80 calves averaged approximately 409 kg. At the termination of the postweaning feeding test, the calves were shipped to a packing plant in Louisville, slaughtered and carcass information obtained on the 48-hr chilled carcass.

The means and standard deviations for the performance and carcass traits are presented in Table 2. Each trait was analyzed, using a least-squares model that included the effects of sire, sex and sire x sex. As for carcass traits, both fat thickness and ribeye area were measured at the 12th rib. Dressing percent, carcass weight per day of age and ribeye area/100 kg of carcass were all calculated, using cold carcass weight.

The analyses of variance for the performance and carcass traits are presented in Table 3. Sire was a significant source of variation for weaning weight and grade, preweaning average daily gain, cold carcass weight, carcass weight per day of age, ribeye area/100 kg carcass, estimated boneless, trimmed retail cuts, fat thickness at 12th rib and estimated percent fat from the kidney and pelvic regions. Sire differences observed for all other traits were small and nonsignificant.

Table 2. — Means and Standard Deviations for Performance and Carcass Traits

Trait	Mean	SD
Performance Traits:		
Prewearing ADG, kg	0.61	0.09
200-day wt, kg	163.6	18.2
Weaning grade ^{a/}	11.3	0.9
Postweaning ADG, kg	0.77	0.08
Wt/day/age, kg	0.77	0.07
Adj final wt, kg	432.7	38.2
Carcass Traits:		
Cold carcass wt, kg	245.0	22.7
Carcass wt/day/age, kg	0.45	0.04
Ribeye area, cm ²	74.2	7.7
Ribeye area, cm ² /100 kg	27.7	2.5
Estimated boneless, trimmed retail cuts, %	50.0	1.4
Carcass conformation ^{b/}	12.5	1.5
Fat thickness at 12th rib, cm	1.45	0.41
Marbling score ^{c/}	5.2	1.4
Estimated fat from kidney and pelvic regions, %	3.4	0.7
Dressing %	58.7	2.1

^{a/} 10 = Average good; 11 = High good

^{b/} 12 = Low choice; 13 = Average choice

^{c/} 5 = Small; 6 = Modest

Sex of calf was a significant source of variation for all performance traits and all carcass traits except marbling score and dressing percent. The least squares means for each trait are presented in Table 4 for the steers and heifers. With respect to the performance traits, steers had a faster preweaning and postweaning rate of gain and were heavier at weaning and at the conclusion of the postweaning feeding period than the heifers. In addition, the steers received slightly higher grades at weaning and had a greater weight per day of age.

Table 4 reveals that the steers had heavier cold carcass weights, larger ribeye areas, greater carcass weight per day of age, larger estimated boneless, trimmed retail cuts and received higher carcass conformation scores. Heifers had greater fat thickness over the 12th rib and a greater percent of estimated fat from the kidney and pelvic regions and larger ribeye area when the ribeye area was expressed per 100 kg of carcass. Marbling scores and dressing percents were equal for steers and heifers.

Table 3 reveals that the sire x sex interaction was not significant for any of the performance or carcass traits. Some of the interaction mean squares approached significance, but most of the F values were less than or slightly larger than 1 in magnitude.

Table 3. — Analysis of Variance for Performance and Carcass Traits

Trait	Mean Squares ^{a/}			
	Sire (7)	Sex (1)	Sire x Sex (7)	Error (62)
Performance Traits:				
Preweaning ADG	0.078*	0.369**	0.035	0.030
200-day wt, kg	2,997.3*	1,2616.3**	1,443.9	1,303.1
Weaning grade	2.1**	10.5**	0.5	0.6
Postweaning ADG	0.023	0.618**	0.019	0.023
Wt/day/age	0.032	0.499**	0.021	0.017
Adj final wt, kg	9,677.8	14,6052.8**	5,798.5	4,868.0
Carcass Traits:				
Cold carcass wt	4,157.7*	4,9446.5**	691.9	1,817.9
Carcass wt/day/age	0.017**	0.157**	0.006	0.006
Ribeye area	1.49	5.35**	1.39	1.28
Ribeye area/100 kg car	0.086**	0.189**	0.039	0.028
Estimated boneless, trimmed retail cuts, %	6.5**	6.9**	1.1	1.4
Carcass conformation	2.9	21.6**	1.7	1.8
Fat thickness at 12th rib	0.060**	0.060**	0.006	0.020
Marbling score	2.32	0.09	1.48	1.85
Estimated fat from kidney and pelvic regions, %	0.72*	6.76**	0.36	0.30
Dressing percent	7.85	0.32	5.58	4.06

a/Numbers in parenthesis represent degrees of freedom.
* P < .05 ** P < .01

Table 4. — Least Squares Means for Steers and Heifers

Trait	Steers	Heifers	Difference (S-H)	Significance of Difference
Performance Traits:				
Preweaning ADG, kg	0.65	0.58	0.07	*
200-day wt, kg	170.5	158.2	12.3	**
Weaning grade ^{a/}	11.7	10.9	0.8	**
Postweaning ADG, kg	0.82	0.74	0.08	**
Wt/day/age, kg	0.81	0.74	0.07	**
Adj final wt, kg	455.0	414.1	40.9	**
Carcass Traits:				
Cold carcass wt, kg	258.2	234.1	24.1	**
Carcass wt/day/age, kg	0.48	0.44	0.04	**
Ribeye area, cm ²	76.1	72.2	3.9	**
Ribeye area, cm ² /100 kg	26.8	28.6	-1.8	**
Estimated boneless, trimmed retail cut, %	50.3	49.7	0.6	**
Carcass conformation ^{b/}	13.1	12.0	1.1	**
Fat thickness at 12th rib, cm	1.35	1.50	-0.15	**
Marbling score ^{c/}	5.2	5.2	0.0	N.S.
Estimated fat from kidney and pelvic regions, %	3.1	3.7	-0.6	**
Dressing %	58.8	58.7	0.1	N.S.

a/ 10 = Average good; 11 = High good * P < .05
b/ 12 = Low choice; 13 = Average choice ** P < .01
c/ 5 = Small; 6 = Modest

SEASONAL VARIATION IN FREE AMINO ACID CONCENTRATION IN SEMINAL PLASMA OF RAMS

C. A. Bradley and R. H. Dutt

Since the major portion of the ejaculate in many species is produced by the accessory glands, studies of the seminal plasma may provide information leading to a better understanding of the mechanism by which elevated temperatures exert undesirable effects on semen quality. The present study was conducted to determine whether seasonal variation exists in concentration of free amino acids in the seminal plasma of rams.

Semen was collected with an artificial vagina from 5 mature Southdown rams twice a week for 5 weeks during August and for 4 weeks during October. Volume of each ejaculate was measured and estimates of percent motile cells were made immediately after collection by examination at 430X under a microscope. Concentration and percent abnormal cells were determined, using a hemocytometer counting chamber. The ejaculates were then frozen and stored until used for amino acid determination. The semen samples were thawed, and the two collections for each week were pooled. Analysis for free amino acids in the seminal plasma was then made on a weekly basis. After being centrifuged at 3600 rpm, the sperm cells were discarded and the seminal plasma was retained for analysis, since it has been reported that 90% of the free amino acids in semen is present in seminal plasma. Levels of 17 different amino acids in the seminal plasma were determined (Table 1).

Table 1. — Concentration of Free Amino Acids in Ram Semen During Two Collection Periods in Micromoles/Milliliter

Amino Acid	Collection Period			
	August ^{a/}		October ^{b/}	
	Average	S.D.	Average	S.D.
Aspartic	1.42	0.27	1.60	0.25
Threonine	1.25	.50	1.73	.77
Serine	1.93	.31	2.02	.50
Glutamic	6.31	.92	5.28	.63
Proline	0.58	.14	0.66	.13
Glycine	1.72	.37	1.46	.25
Alanine	1.96	.22	1.78	.35
Valine	0.74	.13	0.77	.26
Cystine	0.13	.16	0.18	.15
Methionine	0.13	.12	0.05	.02
Isoleucine	0.48	.12	0.61**	.04
Leucine	1.44	.23	1.71	.15
Norleucine	2.50	.00	2.50	.00
Tyrosine	0.15	.06	0.18	.05
Phenylalanine	0.11	.04	0.12	.08
Lysine	1.90	.51	1.98	.15
Histidine	0.59	.11	0.88**	.13
Arginine	0.89	.17	1.21**	.17

^{a/} Average for 5-week collection

^{b/} Average for 4-week collection

* Significantly different from August at $P < .05$

**Significantly different from August at $P < .01$

The mean and standard deviation for each amino acid for the August and the October collection periods are shown in Table 1. The variance between the two periods was analyzed statistically. Levels of arginine and isoleucine were significantly ($P < .05$) higher during October (1.21 and 0.61 versus 0.89 and 0.48 umoles, respectively). The increase in arginine and isoleucine was 36.1% and 27.0%, respectively. Histidine was also significantly ($P < .01$) higher during October (0.88 versus 0.59 umoles/ml.), having increased 48% from August to October. Although no significant differences were found between August and October for the remaining 14 amino acids, the average concentration for all amino acids during August was 1.34, compared with 1.31 umoles/ml during October.

Data from this study indicate that there are seasonal influences on concentration of some free amino acids in the seminal plasma of rams, although concentrations of total free amino acids were not significantly different for the two collection periods. Since amino acid concentration in the seminal plasma has been shown to be dependent upon testosterone production, results of this study suggest that testosterone production in the rams was not affected significantly by the increased environmental temperatures encountered during the summer months. However, the significant variation found in levels of arginine, isoleucine and histidine offers the interesting possibility that changes in these amino acids may be associated with the quality of ram semen and that they may prove useful as indicators of potential fertility.

MOTILITY OF RAM SPERMATOZOA AFTER STORAGE IN GLYCEROL OR PROPYLENE GLYCOL DILUTORS AT 4° AND -40°C

Paul D. Deaton and R. H. Dutt

Improved techniques for synchronizing estrus offer further opportunity for use of artificial insemination in sheep. Increased efficiency in reproductive potential may be realized if ram semen could be frozen and stored without significant impairment of fertilizing ability of sperm cells. Thus, it may then be feasible to collect ram semen during the season when fertility is highest for use during periods of lowered fertility.

Motility of ram sperm after storage at 4° and -40°C was studied in diluents containing glycerol or propylene glycol. Semen was collected from Southdown rams and pooled. Initial motility and concentration were determined for each pooled sample. The pooled semen was extended 1:20 in reconstituted skim milk containing 4, 8 or 16% glycerol or similar levels of propylene glycol. Average percent of motile cells stored in dilutors containing 4, 8 or 16% glycerol and undiluted control after 24 hours' storage at 4°C was 39.0, 35.5, 18.5 and 21.0, respectively (Table 1). After 72 hours' storage, average percent motile cells was 8.9, 9.5, 3.2 and 4.1, respectively, for the four treatments. Motility of sperm after 24 and 72 hours' storage in the dilutors containing 4% and 8% glycerol was significantly ($P < .01$) higher than that for sperm in the 16% glycerol diluent or for the undiluted control. Average percent motile sperm after 24 hours of storage at 4°C in dilutors containing 4, 8 or 16% propylene glycol and in the undiluted control was 43.0, 39.0, 24.5 and 21.0, respectively. After 3 days' storage, average percent of motile cells was 14.8, 17.1, 6.6 and 4.1 for the four groups, respectively. Motility of the sperm after 24 and 72 hours' storage in the 4% and 8% propylene glycol dilutors was significantly ($P < .01$) higher than for sperm in the 16% propylene glycol dilutor or the undiluted control. Motility of sperm diluted in propylene glycol was also significantly ($P < .01$) higher than that diluted in comparable levels of glycerol when stored at 4°C.

When stored for 10 minutes at -40°C, the average percent of motile sperm cells stored in dilutors containing 4, 8 or 16% glycerol was 36.5, 40.0 and 21.2, respectively. Motility of sperm in diluents containing 4% and 8% glycerol was significantly ($P < .01$) higher than for sperm in 16% glycerol dilutors. Percent of motile sperm diluted in 8% propylene glycol was significantly ($P < .01$) higher than that stored in the 4% or 16% propylene glycol dilutors (11.0, 5.2 and 3.5, respectively). Motility of sperm stored in glycerol was significantly ($P < .01$) higher than that stored in corresponding levels of propylene glycol.

Table 1. — Percent Motile Sperm Cells after Storing at 4°C or at -40°C in Dilutors Containing Different Concentrations of Glycerol or Propylene Glycol

Stored At:	Undiluted Control	Type of Dilutor					
		Glycerol			Propylene Glycol		
		4%	8%	16%	4%	8%	16%
4°C for 24 hours	21.0	39.0	35.8	18.5	43.0	39.5	24.5
4°C for 72 hours	4.1	8.9	9.5	3.2	14.8	17.1	6.6
-40°C for 10 minutes*	---	36.5	40.0	21.2	5.2	11.0	3.5

*None of the samples had motile cells after storing for 24 hours at -40°C.

Results from this study show that reconstituted skim milk diluents containing 4% or 8% glycerol or propylene glycol will maintain the motility of ram sperm longer after storing at 4°C than will 16% glycerol or propylene glycol. No motile sperm cells were observed in any of the samples after 24 hours' storage at -40°C in either glycerol or propylene glycol diluents.

EFFECT OF VAGINAL SPONGES AND PMS ON REPRODUCTIVE PERFORMANCE IN SPRING-BRED YEARLING AND AGED CROSSBRED EWES

W. P. Deweese, R. H. Dutt and G. L. M. Chappell

Aged ewes normally surpass yearling ewes in reproductive performance when managed in a conventional manner. This experiment was designed to compare the reproductive performance of spring-bred yearling and aged ewes after treatment with progestogen-impregnated vaginal sponges and PMS.

Eighty-one yearling crossbred ewes were randomly divided into three equal groups. The first group was treated with impregnated vaginal sponges for 14 days while the second group received vaginal sponges for 14 days plus 750 IU PMS subcutaneously 24 hours after sponge removal. The third group served as a control. Eighty-two aged crossbred ewes were divided into three groups and treated in the same manner as the yearlings. One-half of each group treated with vaginal sponges received sponges treated with 40 mg. of medroxyprogesterone acetate while the other half received sponges treated with 60 mg of the hormone.

The results are shown in Tables 1 and 2. The performance of the aged ewes (Table 2) was consistently superior to that of the yearling ewes (Table 1). A higher percent of the aged ewes lambed with more lambs being born per ewe.

Table 1. — Lambing Performance of Yearling Ewes

	Treatment				
	Sponges only		Sponges + PMS		Control
	40 mg	60 mg	40 mg	60 mg	
No. of ewes exposed	14	13	13	14	27
No. of ewes lambed	1	6	9	9	2
Lambing rate	1.0	1.0	1.44	1.0	1.0
Lambing %	7.14	46.15	100.0	64.29	7.4

Table 2. — Lambing Performance of Aged Ewes

	Treatment				
	Sponges only		Sponges + PMS		Control
	40 mg	60 mg	40 mg	60 mg	
No. of ewes exposed	14	13	13	14	28
No. of ewes lambd	10	8	8	12	7
Lambing rate	1.30	1.50	1.75	1.42	1.43
Lambing %	92.9	92.3	107.7	121.4	35.7

RELATIONSHIP BETWEEN GESTATION LENGTH AND NUMBER OF LAMBS BORN

F. A. Thrift and R. H. Dutt

Eight hundred and eighty-eight gestation lengths obtained over a 19-year period on blackfaced crossbred ewes were analyzed to determine the relationship, if any, between gestation length and number of lambs born. All ewes were bred over a relatively short period of time to Southdown rams and exact breeding and lambing dates were kept on these ewes. Thus, it was possible to determine the gestation length for each ewe. As each ewe lambd, the number of lambs born, together with their birth weights, were recorded.

To determine the relationship between gestation length and number of lambs born, the data were analyzed by two least-squares procedures. The first analysis was conducted to determine the average gestation length for ewes giving birth to singles, twins and triplets. The statistical model utilized to describe the gestation length data included both year and number of lambs born (1 = single; 2 = twins; 3 = triplets) as discrete variables. The second analysis was conducted to determine the relationship between total pounds of lambs born and gestation length. This model utilized to describe the gestation length data included year as a discrete variable and total birth weight of all lambs born as a continuous variable. The total birth weight of lambs refers to the combined weight of all lambs born to a particular ewe within a year. In the case where a ewe had twins or triplets within a year, the birth weights of the twins or triplets were added together to obtain total birth weight.

The results of the first analysis revealed that the average gestation lengths were 145.2, 145.1, 145.5 days, respectively, for ewes giving birth to singles (599), twins (281) and triplets (10). The numbers in parenthesis refer to the number of observations that went to make up each average gestation length.

The results of the second analysis revealed that the regression of gestation length on total birth weight was $0.05 \pm .02$. Thus, for each one pound of additional lamb at birth, gestation length increased approximately 0.05 day.

USE OF HORMONES TO STIMULATE BREEDING ACTIVITY IN ANESTROUS YEARLING EWES

R. E. Renfro and R. H. Dutt

Intravaginal sponges containing 6-methyl-17-acetoxypregesterone (MAP) in conjunction with pregnant mare serum gonadotrophin (PMSG) and human chorionic gonadotrophin (HCG) were used to initiate breeding activity in one-year-old ewes. The trial was conducted during May. Thirty-eight, crossbred ewes were randomly allotted into two treatment groups and a control group consisting of 13, 13 and 12 ewes, respectively. Ewes in one group (3-day group) were slaughtered 3 days after breeding or 5 days after end of treatment, if they did not show

estrus. Ewes in the second group (40-day group) were slaughtered 40 days after end of treatment. The 3- and 40-day ewes were treated for 14 days with intravaginal sponges containing 40 mg of MAP. A subcutaneous injection of 500 IU of PMSG and an intramuscular injection of 500 IU of HCG was administered on days 15 and 16, respectively, to ewes in both treated groups. Ewes in estrus were artificially inseminated with 1.0 ml of freshly collected ram semen. All ewes were checked daily for occurrence of estrus with aproned teaser rams from day of PMSG injection until slaughter. Controls were slaughtered at the time of the 40-day ewes to determine whether ovulation had occurred. Measurement of the reproductive tracts from all ewes was made in the laboratory.

In the 3-day group 77% of the ewes came into estrus and 54% of the 40-day ewes (Table 1). However, all ewes in the 3-day group had ovulated prior to slaughter with an ovulation rate of 1.15. Of the 15 ova recovered from ewes in this group, 47% showed cleavage. In 40-day ewes only one ewe was pregnant of the 7 which had exhibited estrus and were bred. None of the control ewes came into estrus, and at time of slaughter no corpora lutea were found on the ovaries of any of these ewes.

Table 1. — Estrous Activity and Breeding Performance of Treated Ewes

3-day Group ^{a/}						40-day Group ^{b/}		
No. of Ewes	Ewes in Estrus	Ewes Ovulating	Ovulation Rate	Ova Recovered		No. Ewes	Ewes Bred	Preg-nant
				No.	% Fertile			
	%	%					%	%
13	77	100	1.15	15	47	13	54	14

^{a/} Treatment consisted of intravaginal sponges containing 40 mg of MAP for 14 days followed by injections of 500 IU of PMSG and 500 IU of HCG on days 15 and 16, respectively. Ewes were slaughtered 3 days following artificial insemination.

^{b/} Treatment same as 3-day group except ewes were slaughtered at 40 days following artificial insemination.

^{c/} Based on number of ewes in estrus and bred.

A comparison of reproductive tract size is presented in Table 2. The hormone treatment resulted in an increase in weight of reproductive tracts in 3- and 40-day ewes. The increased weight of ovaries and follicular fluid in 40-day ewes is evidence of hormone stimulation. The failure to observe corpora lutea in any ewes except those pregnant is evidence that cyclic activity was not initiated by the treatment.

Table 2. — Comparison of Size of Reproductive Tracts in Control and Treatment Ewes

Treatment Groups	Tract Weight, gm	Uterine Horn Diameter, mm	Weight of Ovaries, gm	Weight of Follicular Fluid, gm
3-day	29.9	11.7	1.03	0.14
40-day ^{a/}	32.6	13.0	1.65*	0.36*
Control	24.5	12.4	1.14	0.27

^{a/} Averages are based on only the 12 nonpregnant ewes.

* Significantly ($P < .05$) different from all other groups.

SEMEN CHARACTERISTICS OF SOUTHDOWN RAMS FED A CHLOROHYDRIN (3-CHLORO-1,2-PROPANEDIOL)

Jack L. Kreider and R. H. Dutt

It has been reported that the chlorohydrin (3-chloro-1,2-propanediol) has an anti-fertility effect when fed to males of certain laboratory species. The effects on semen traits of rams fed this compound are reported in the following study.

Five mature Southdown rams were fed the chlorohydrin daily in gelatin capsules at the rate of 25 mg/kg of body weight during a 25-day treatment period. Semen was collected from each ram in an artificial vagina every other day for 10 days (five collections) prior to and during treatment. Three collections were made over a 10-day period after end of treatment. Percent of motile cells was estimated approximately 15 minutes after collection and the volume was recorded. Sperm concentration and percent abnormal cells were determined by counting in a hemocytometer under a high-power microscope. Fructose levels in seminal plasma collected during the treatment period were compared with post-treatment levels.

Average values for semen traits during pretreatment, treatment and post-treatment periods are given in Table 1. Semen volume was significantly ($P < .05$) higher after treatment than during the other two periods. Sperm cell concentration was not affected significantly by the treatment, indicating the treatment probably had no effect on spermatogenic activity. Percent of motile sperm cells declined significantly ($P < .01$) during treatment.

Table 1. — Average Semen Characteristics of Rams Before, During and After Treatment with 3-Chloro-1,2-Propanediol

Ram No.	Semen Volume (ml)	Motile Cells (%)	Sperm Concentration (10,000 per mm ³)	Abnormal Cells (%)
<u>Pretreatment period</u>				
722	0.62	74	379.0	11.1
728	.80	62	350.8	5.3
730	.90	56	441.4	11.2
731	.52	58	432.2	7.2
732	.70	40	398.6	4.6
Average	.71	58	399.8	7.9
<u>Treatment period</u>				
722	0.92	16	365.6	16.8
728	.68	22	353.8	17.9
730	.68	14	427.2	17.1
731	.68	22	453.6	23.7
732	.86	16	426.0	20.2
Average	.78	18.1	405.2	19.2
<u>Post-treatment period</u>				
722	0.77	63	271.0	26.3
728	.93	63	389.0	10.6
730	.80	67	450.0	19.4
731	.97	70	517.0	14.9
732	.83	73	518.7	15.0
Average	.86	67.3	429.1	17.2

However, during post-treatment tests the percent of motile cells was higher ($P = .01$) than during pretreatment tests. A marked decline in percent motile cells was noted as early as the third day after starting treatment. Percent abnormal cells were significantly ($P = .01$) higher during and after treatment. There was no significant difference between treatment and post-treatment semen fructose levels, and libido was not adversely affected by treatment.

The rapid decline in sperm motility in treated rams and the absence of differences in treatment and post-treatment semen fructose levels suggests that the effect of the chlorohydrin on sperm motility occurred at the epididymal level and not during spermatogenesis or through altered accessory gland function.

SOURCES OF VARIATION IN SEMEN CHARACTERISTICS OF YEARLING SOUTHDOWN RAMS

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

As part of a study in a flock of Southdown sheep where selection has been practiced for earlier lambing, semen evaluation tests have been made each year on five early-born yearling rams from three sire groups. Exceptions occurred in 1958 when only two sire groups were used and in 1960 when all sire groups did not have five males available for testing.

Semen collections were made with an electroejaculator during three consecutive weeks in July. Approximately 1 milliliter of semen was taken at each collection, and percent motile cells, sperm cell concentration, and percent of abnormal cells were determined.

Results of the semen tests for 1958-68 are shown in Table 1.

Table 1. — Results of Semen Evaluation Tests in Yearling Southdown Rams

Year	Volume per Collection, ml	Motile Cells, %	Sperm Cell Concentration, 10,000/mm	Abnormal Cells, %
1958	0.75	61	151.8	29
1959	0.90	59	249.6	29
1960	0.87	65	184.4	23
1961	0.88	53	133.9	37
1962	0.98	59	165.9	24
1963	0.93	58	170.3	16
1964	0.98	48	135.9	30
1965	1.08	67	249.0	10
1966	1.04	46	185.7	17
1967	1.00	30	137.8	34
1968	1.03	49	195.3	15

Each of the semen traits was analyzed using a variance components model that included the effects of years, sires within years, and rams within sires within years. This procedure was utilized to partition the total variance into component parts attributed to each of these effects. For each of these effects, mean squares were equated to expected mean squares and year, sire and ram variance components estimated. These variance components were then expressed as a percentage of the total variance; the results are presented in Table 2 for each of the 4 traits. Table 2 reveals that for each trait the sire contributed less to the total variance than either years or rams within sires. The large percentage of variance

attributed to rams within sires for each of the tracts is to be expected, since this value includes three-fourths of the additive genetic variance plus whatever dominance variance is present and all the environmental variance remaining after removal of the year effect. The variation attributed to years is probably due to such factors as temperature and humidity at the time of semen collection and evaluation. The sire variation is an estimate of the genetic variation associated with these traits.

Table 2. — Percent of Total Variation in Semen Characteristics Attributed to Years, Sires/Years and Rams/Sires

Source	Sperm Cell Concentration	Semen Volume	Motile Cells	Abnormal Cells
	(percent)			
Total	100.0	100.0	100.0	100.0
Among years	15.0	9.8	27.0	16.4
Among sires/years	7.1	9.7	3.2	15.7
Among rams/sires	77.9	80.5	69.8	67.9

INFLUENCE OF THE PHOTOPERIOD ON OVULATION, FERTILITY AND EMBRYO SURVIVAL RATES IN EWES

R. H. Dutt, P. R. Dame and R. E. Renfro

Studies reported previously show that exposing ewes to different photoperiods for one estrous cycle during the breeding season affects ovulation and lambing rates. There was no effect of treatment on occurrence of estrus or on embryo survival rates. The study reported herein was carried out to determine the effect of longer periods of treatment, i.e., for two complete estrous cycles. The study was conducted during October and November.

Twenty-eight ewes were kept in continuous light for two estrous cycles before breeding, 28 ewes were kept without light (restricted-light group) for two complete cycles, except for a 2-hour period each day when they were checked for estrus and fed. Twenty-eight ewes were kept as controls. Yearling and two-year-old dark-faced Northwestern ewes were stratified among treatments. All ewes were checked daily for estrus with aproned teaser rams. The constant-light group was kept in a pen equipped with fluorescent lighting, which provided light intensity 18 inches from the floor, ranging from 10 foot-candles in corners to 40 foot-candles beneath the lights. Control ewes were housed in a similar pen without artificial lighting, and the restricted-light group was kept in a darkened room equipped with fans for adequate air circulation.

Ewes in all groups were artificially inseminated, starting October 27. One-half of the ewes in each group were slaughtered 3 days after breeding for ovulation and fertility data, and the remaining ewes in each group were retained on their respective light treatments until 20 days after breeding. The latter ewes provided data for estimating the influence of light on embryo survival. Ewes were group fed similar amounts so that nutrition was controlled on all treatment groups.

Ovulation and fertilization rates are shown in Table 1, and percentage of ewes lambing and embryo survival rates are shown in Table 2. Ovulation and lambing rates were 15% and 30% higher, respectively, for the ewes exposed to restricted light than for ewes kept on the continuous-light treatment. A slightly higher fertilization rate and higher embryo survival in the restricted-light ewes account for the greater increase in lambing rate in this group. In earlier studies when the controlled photoperiod lasted for only one estrous cycle, ovulation and lambing rates were higher in ewes exposed to continuous light. Seemingly, increasing

the photoperiod for short duration during the breeding season may have a beneficial effect on these two reproductive traits. Exposure to continuous light for periods beyond one estrous cycle had a depressing effect on ovulation and lambing rates in the present study.

Table 1. — Ovulation and Fertility Rates in Ewes Exposed to Different Photoperiods

Item	Treatment Group		
	Control	Restricted Light ^{a/}	Continuous Light ^{b/}
No. of ewes	14	14	14
Ovulation rate	1.64	1.71	1.50
Ova fertilized, %	95.6	100.0	90.5

^{a/} Ewes exposed to 22 hours of darkness and 2 hours of light daily for two complete estrous cycles before breeding.

^{b/} Ewes exposed to continuous light for two complete estrous cycles before breeding.

Table 2. — Estimated Embryo Survival and Lambing Rates in Ewes Exposed to Different Photoperiods

Item	Treatment Group		
	Control	Restricted Light ^{a/}	Continuous Light ^{b/}
No. of ewes	14	14	14
Ewes lambing, %	92.8	92.8	100.0
Estimated embryo survival, %	95.7	100.0	95.9
Lambing rate	1.57	1.86	1.43

^{a/} Ewes exposed to 22 hours of darkness and 2 hours of light daily for 2 complete estrous cycles before breeding and for 20 days after breeding.

^{b/} Ewes exposed to continuous light for two complete estrous cycles before breeding and for 20 days after breeding.

3.8M--7-69

ACKNOWLEDGMENTS

Research in the Animal Sciences Department during the past year has been supported by grants-in-aid provided by the following organizations:

Abbott Laboratories, North Chicago, Ill.
Allied Chemical Corporation, New York, N. Y.
American Dairy Association, Chicago, Ill.
American Jersey Cattle Club, Columbus, Ohio
Charles Pfizer and Company, Terre Haute, Ind.
Distillers Feed Research Council, Cincinnati, Ohio
Eli Lilly and Company, Indianapolis, Ind.
Fischer Packing Company, Louisville, Ky.
Foremost-McKeeson Foundation, San Francisco, Calif.
Kentucky Artificial Breeding Assoc., Louisville, Ky.
Kentucky Dairy Products Association, Louisville, Ky.
Moorman Manufacturing Company, Quincy, Ill.
National Association of Animal Breeders, Columbia, Mo.
Phelps Dodge Refining Corporation, New York, N. Y.
Shell Chemical Company, New York, N. Y.
U. S. Public Health Service

Ingredients, supplies and services have been donated by the following firms in connection with the past year's Animal Sciences research program:

Abbott Laboratories, North Chicago, Ill.
Allied Chemical Corporation, New York, N. Y.
American Cyanamid Company, Princeton, N. J.
Ayerst Laboratories, New York, N. Y.
Charles Pfizer and Company, Terre Haute, Ind.
Commercial Solvents Corporation, Terre Haute, Ind.
Corn Products Company, Argon, Ill.
Distillers Feed Research Council, Cincinnati, Ohio
Distillation Products Industries, Rochester, N. Y.
Eastman Chemical Products, Kingsport, Tenn.
Eli Lilly and Company, Indianapolis, Ind.
Fischer Packing Company, Louisville, Ky.
Field Packing Company, Owensboro, Ky.
General Foods Corporation, Jello Division, Woburn, Mass.
Henry Fruechtenicht Company, Inc., Louisville, Ky.
Hoffman-LaRoche, Nutley, N. J.
Kentucky Artificial Breeding Assoc., Louisville, Ky.
Merck and Company, Inc., Rahway, N. J.
Phelps Dodge Refining Corporation, New York, N. Y.
Proctor and Gamble Company, Cincinnati, Ohio
Shell Chemical Company, New York, N. Y.
Swift and Company, Chicago, Ill.
The Upjohn Company, Kalamazoo, Mich.
Wallerstein Company, Staten Island, N. Y.