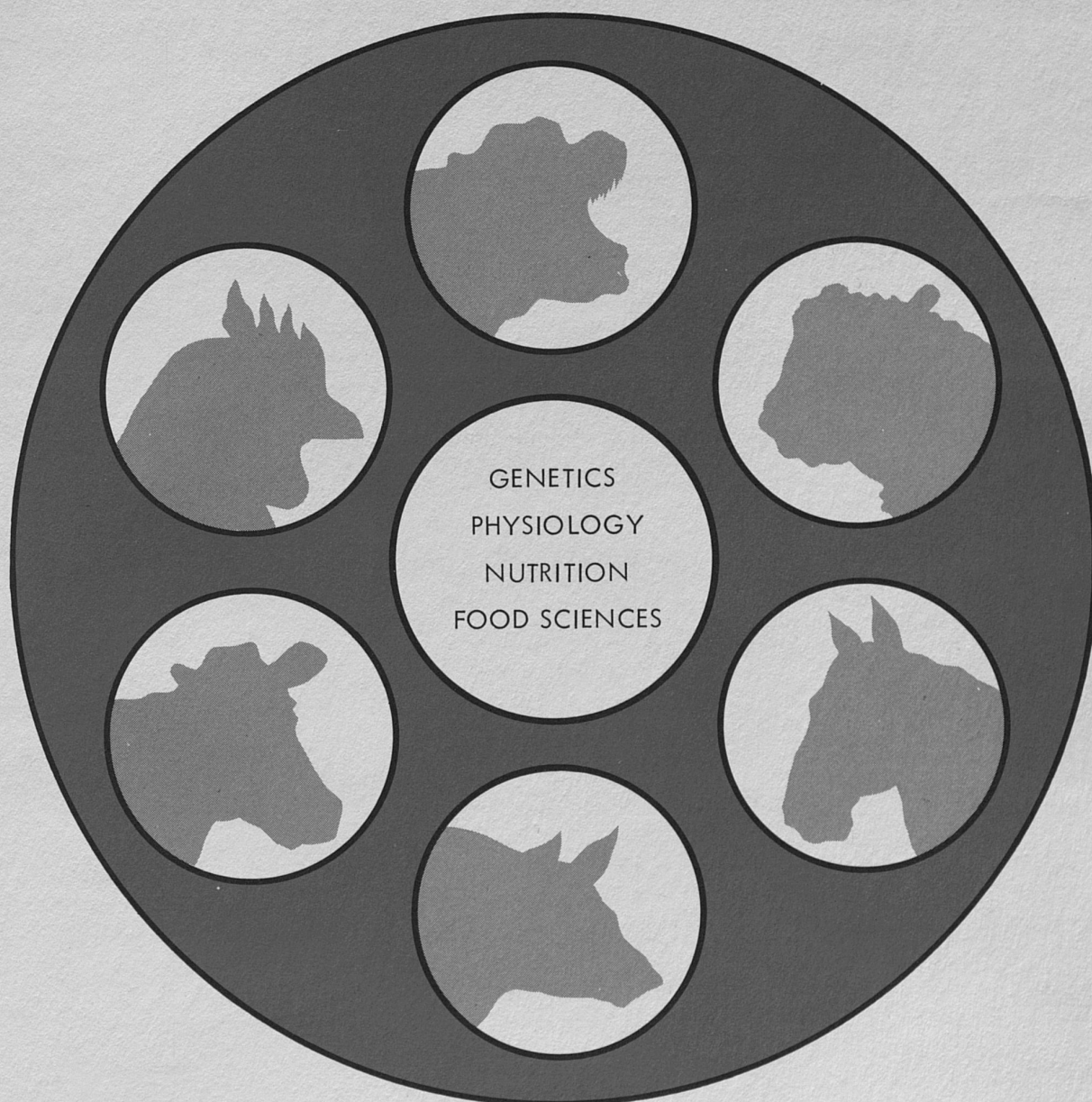


Kentucky Animal Science Research Report-1968

UNIVERSITY OF KENTUCKY * AGRICULTURAL EXPERIMENT STATION



PROGRESS REPORT 176

PROGRAMS FOR 1968 ANIMAL SCIENCES FIELD DAYS

DAIRY FIELD DAY

July 2, 1968—University Coldstream Dairy Center, Lexington

- Conducted tours of demonstrations and exhibits showing recommended practices and solutions of current problems facing the dairy industry beginning at 10:00 a.m.
- Lunch provided by American Dairy Association of Kentucky, Louisville, Aubrey Feed Mills, Louisville, and Southern States Cooperative, Lexington, Sealtest Foods, Louisville, and Kyana Milk Producers Association, Louisville.
- Address -- "Dollars and Sense of Programmed Dairy Herd Health" - Dr. David A. Morrow, Department of Animal Science, Cornell University, Ithaca, N. Y.

LIVESTOCK FIELD DAYS

July 10, 1968—University Coldstream Farm, Lexington

July 12, 1968—Western Kentucky Substation Farm, Princeton

- Conducted tours of beef, sheep, swine and horse 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 -- "Future of Agriculture in Kentucky" - Honorable Louie B. Nunn, Governor, Commonwealth of Kentucky

KENTUCKY
ANIMAL SCIENCES RESEARCH REPORTS
1968

PROGRESS REPORT 176

July 1968

UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

CONTENTS

	Page
 <u>ANIMAL FOODS SECTION</u>	
Keeping Quality of Fluid Dairy Products Obtained at Retail Outlets . . .	5
Effect of Sanitizers on the Freezing Point of Milk	7
Factors Affecting Consumer Acceptance of Chocolate-Flavored Milk . .	8
The Effect of DDT, Dieldrin, and Heptachlor on the Growth of Selected Bacteria	9
Effect of Casein on Dechlorination of DDT and Inhibition of Growth by Heptachlor	10
Effect of 2,3,5-Triphenyl-Tetrazoloim Chloride (TTC) in Plating Media on the Enumeration of Psychrophiles	11
Effect of Cocoa Powder on the Growth of Bacteria	11
Effect of <u>Bacillus Subtilis</u> Protease and Sodium Tripolyphosphate on the Quality of Aged Hams	13
Effects of Aging Temperature on Aged Ham Quality	14
Effect of Fresh Ham Quality and Aging Temperature on Quality of Aged Hams	15
Effects of Salt, Moisture and Aging Time on the Viability of <u>Trichinella Spiralis</u> in Dry-cured Hams	18
Effect of Fatness and Fresh Pork Quality on Yield and Quality of Ham and Bacon	19
Carcass Traits of Lambs of Different Gaining Ability and Slaughter Weights	22
Heritability Estimates of Some Lamb Carcass Traits	24
Effects of Rate of Gain and Weight at Slaughter on Certain Quality Characteristics of Lambs	25
 <u>GENETICS AND PHYSIOLOGY SECTION</u>	
Selection for Oxygen Consumption of Three-week-old Chickens	28
Measurement and Selection of Economically Important Traits in Beef Cattle	28
An Evaluation of Six Chemical Tests for Pregnancy in Cattle	30
A Survey of Dairy Farmers Concerning Breeding and Management Practices	31
The Effect of Irrigation and Nitrogen Fertilization on the Nitrate Content of Sudex Forage	32
Effect of Herd Size on Fertility and Delayed Returns	32

GENETICS AND PHYSIOLOGY SECTION (continued)

The Relationship Between Nitrate Content of Forages and Dairy Herd Fertility	32
Effect of Pronase on Subsequent Development of Mouse Embryos	33
Feed Intake and Embryo Survival in Gilts	33
Selective Breeding for Earlier Lambing in Southdown Sheep	35
Effects of Unilateral Castration on Body Weight and Accessory Gland Development in Ram Lambs	37
Comparison of MAP and Progestogen Impregnated Vaginal Sponges for Synchronizing Estrus in Ewes	39
Pituitary Gonadotropin Levels at Different Stages of the Estrous Cycle of the Ewe	40
Oxygen Consumption by Sperm Cells from Heat-stressed Rams	41
Causes of Infertility in Beef Cows	42

ANIMAL NUTRITION SECTION

The Rehabilitation of Cage Laying Hens	44
Effects of Rearing Method and Protein Phase Feeding on the Reproductive Performance of Cage Laying Hens	46
Effect of Pantothenic Acid Level on the Utilization of Energy and Nitrogen by the Chick	48
Effects of Protein Level of the Diet on the Reproductive Performance of Japanese Quail (<i>Corturnix corturnix japonica</i>)	51
Apparent Protein Digestion Anterior and Posterior to Equine Cecal Fistulas	53
Digestion of Energy Sources by Equine Intestinal Microorganisms	55
Volatile Fatty Acids in Equine Cecal Fluid	56
Performance of S.P.F. Yorkshire Herd at West Kentucky Substation from 1963 to 1967	57
Effect of Protein Sources and Levels and Oral Iron for the Sow on Reproductive Performance	60
Effect of Dietary Fat, Protein, Cholesterol and Ascorbic on Serum and Tissue Cholesterol and Serum Lipids in Swine	62
High Protein Rations for Swine	62
Protein Levels for Growing-finishing Pigs on Concrete	63
A Comparison of Opaque-2 and Normal Corn for Pigs	64
Comparison of Free-choice and Complete-mixed Rations for Growing-finishing Swine	64

ANIMAL NUTRITION SECTION (continued)

	Page
Interrelationships of Copper and Molybdenum on Performance of Growing-finishing Pigs	65
Levels of Phosphorus for Growing-finishing Pigs	65
Utilization of Urea by Lactating Dairy Cows	66
Sulfur, Nitrogen and Amino Acid Balance, and Digestibility of Low Sulfur and Sulfur Supplemented Diets Fed to Lactating Cows	67
Properties of Toxic Fescue Extracts	68
Establishment of Microbial Activity in Pre-weaned Lambs	68
Growth and Development of Early Weaned Lambs	70
Intake and Performance of Young Lambs	70
Performance and Carcass Characteristics of Early Weaned Lambs Slaughtered at Different Weights	72
Influence of Vitamin A Deficiency on Renal Function in Ewes	74
Biliary Secretion of Metabolites of Vitamin A and Beta-Carotene in Sheep	74
Losses of Vitamin E from the Pre-intestinal Digestive Tract of Steers .	75
Effect of Concentrate Level on Pre-intestinal Disappearance of Vitamin A	76
Effects of Iodinated Casein and Tapazole on Vitamin A Turnover in Steers	77
Sulfobromothalein (BSP) Excretion by Sheep During Metabolic Stress . .	77
Protein Status of Sheep and Levels of Blood Acetate and Glucose	78
Post-ruminal Cellulose Digestion in Sheep	79
Rumen Metabolite Utilization by Mature Rats	80
Proline Metabolism During Cellulose Digestion by Rumen Microorganisms	81
Volatile Fatty Acid Concentrations in Ruminal Fluid of Steers Fed Chlortetracycline or Tylosin	81
Abomasal Nitrogen in Steers Fed Urea Rations	82
Abomasal Nitrogen in Wethers Fed Different Protein Sources	83
Effect of Oyster Shell With and Without Roughage in Beef Finishing Rations	84
Urea and Molasses Supplementation of Ground Ear Corn Rations for Feedlot Steers	86
Level of Intake and Feedlot Performance of Steers Fed Soybean Meal or Urea	88

ANIMAL FOODS SECTION

KEEPING QUALITY OF FLUID DAIRY PRODUCTS
OBTAINED AT RETAIL OUTLETS

B. E. Langlois, A. W. Rudnick, T. R. Freeman

In an attempt to learn what the housewife can expect when buying fluid dairy products, a 4-year study was undertaken. Samples of homogenized milk, low-fat milk, chocolate milk, skimmilk, half-and-half and whipping cream were obtained from retail outlets in Lexington, Ky. These were analyzed for flavor and bacteriological qualities both before and after storage in the laboratory.

Procedure

The samples obtained were evaluated for flavor on the day purchased and after 4, 7, 10 and 14 days' storage at 45F. Samples scoring below 36.0 (40.0 perfect) were considered unacceptable.

Bacteriological analyses were made on the day purchased and after storage for 7 days at 45F.

Results

Average results obtained for each product examined are shown in Table 1.

Individual samples ranged in age from 0 (fresh) to 28 days old when purchased. Products with the highest turn-over, i.e. homogenized and low-fat milk, were freshest at time of purchase. Keeping quality (shelf-life in the home) after purchase was directly related to the age of the product when it was purchased.

Homogenized milk, which is the industry's biggest seller, had the poorest flavor when purchased. In general, however, flavor score at time of purchase cannot be used to predict shelf-life.

Except for chocolate milk, whipping cream and half-and-half had the most samples exceeding the legal bacteriological standard at time of purchase. There was little relationship, however, between total numbers of bacteria, or initial coliform numbers, and the shelf-life of the product. On the other hand, the presence of large numbers of psychrophilic organisms initially was a sign of a short keeping quality for the product.

The greatest percentage (7%) of samples of homogenized milk were unacceptable because of flavor when purchased. However, except for low-fat milk the rate of spoilage of homogenized milk during storage was less than that for the other products studied.

The results of this study show that the housewife is faced with these gambles when she buys fluid dairy products:

Table 1. — Comparison of the Keeping and Bacteriological Quality of Fluid Dairy Products Obtained at Retail Outlets

No. of Samples Examined	Pur- chased Age	Days Kept ^a / Average	Initial Flavor	Coliform Count 10/ml	Standard Plate Count 20T/ml	Flavor Score Less Than 36.0					
						Percent					
						0	4	7	10	14	
Homogenized milk	144	3.9	7.7	37.9	6	13	7	17	31	58	74
Skimmilk	100	5.3	8.0	38.3	2	12	3	9	26	57	79
Low-fat milk	90	4.3	9.5	38.5	3	11	0	4	21	39	62
Chocolate milk	99	5.9	6.0	38.0	8	33	4	21	43	74	93
Whipping cream	89	7.7	6.2	38.1	21	37	6	25	55	70	78
Half-and-half	100	6.4	5.8	38.3	14	29	4	24	51	68	91

^a/From date of purchase.

^b/Storage at 45F.

1. One chance in 20 that the product will be spoiled when she gets home.
2. One chance in 8 that it will spoil after 4 days in the refrigerator.

These odds go to 1 in 4 or 5 that chocolate milk or high-fat products will spoil in this time.

3. The odds are from 1 to 5 to "even money" that the product will not keep for a week.

This study indicates that retail quality of many dairy products is not sufficient to meet the challenge of "dairy substitutes."

EFFECT OF SANITIZERS ON THE FREEZING POINT OF MILK

T. R. Freeman and J. L. Bucy

The freezing point (FP) of normal milk is one of its most constant characteristics. Consequently, the FP determination of milk is the most widely used method of detecting the presence of added water. To use this control technic intelligently it is helpful to have an understanding of the possible effect on the FP of milk of other contaminants that might gain access to such milk.

To meet sanitary requirements imposed upon them, milk producers find it necessary to make extensive use of chemical sanitizers in readying milking and milk handling equipment for daily use. Inevitably, traces of sanitizers will, from time to time, be transferred from equipment to milk supplies. The purpose of these experiments was to find out if the presence of small amounts of commonly used sanitizers would change the FP of the milk.

Three types of sanitizers were investigated: sodium hypochlorite, iodophor, and quaternary ammonium chloride. These were each added to fresh milk in concentrations of 0, 10, 25, and 50 ppm. Freezing point measurements were made after 0, 24, and 48 hr. Eight trials were conducted with each sanitizer.

Results obtained are summarized in Table 1. Apparently, the quaternary ammonium sanitizers had no effect on the FP of milk. The iodophor and the hypochlorite both lowered the FP slightly, with the iodophor having slightly more effect than the hypochlorite. Seemingly, there was no difference whether the FP determination was made immediately after adding the sanitizer or 48 hr later. Not shown in the table is the observation that Jersey milk seemed to be affected slightly more than was Holstein milk—although the difference was so small that it probably is not significant. The presence of traces of sanitizer apparently had slightly greater effect on the FP of late-lactation milk than of early lactation milk, but again the difference was probably too small to be significant.

Table 1. — Changes in Freezing Point ($^{\circ}$ C) of Milk After Adding Different Amounts of Sanitizers

Hours	10 ppm	25 ppm	50 ppm
Quaternary Ammonium Chloride			
0	+.001	+.001	-.001
24	+.001	.000	-.001
48	+.001	+.001	.000
Ave	+.001	+.001	-.001
Iodophor			
0	-.004	-.009	-.015
24	-.003	-.007	-.015
48	-.002	-.006	-.014
Ave	-.003	-.007	-.015
Sodium Hypochlorite			
0	-.001	-.005	-.010
24	-.002	-.005	-.013
48	-.002	-.005	-.010
Ave	-.002	-.005	-.011

FACTORS AFFECTING CONSUMER ACCEPTANCE OF CHOCOLATE-FLAVORED MILK

O. Hampton, B. E. Langlois and A. W. Rudnick

Sale of chocolate-flavored milk has never reached the level expected by the dairy industry, and the reasons for this are not known. A recent survey of this station indicated a lack of uniformity in the composition of chocolate-flavored milk.

This study was made to determine the role of fat and solids-not-fat (SNF) in the consumer acceptance of chocolate-flavored milk.

Procedure

With seven commercial cocoa powders, chocolate-flavored milks containing 0, 2 and 3.5% milk fat and 9, 10 and 12% SNF at each of the three fat levels were prepared.

Milk samples were evaluated for flavor 2 and 4 days after preparation by a panel of 5 experts and 15 consumers. In addition to flavor evaluations, the samples were analyzed for viscosity, pH, chocolate level, and amount of fat and SNF.

Results

The pH of the samples was not affected by amount of fat and SNF, cocoa powder, or time after manufacture.

The chocolate level depended on the type of cocoa powder. In general, the stronger the cocoa powder the higher the chocolate level.

The viscosity increased with an increase in SNF, fat and time after preparation.

The amount of SNF had a direct relationship to acceptance. At all three fat contents, the more SNF present, the greater the preference. More fat in the samples increased the preference. Amount of total milk solids seemed to have the greatest effect on preference. Samples containing 3.5% fat and 12% SNF (most total milk solids) had the highest flavor score, followed by those of 3.5% fat and 10% SNF and 2.0% fat and 10% SNF.

The flavor score of the chocolate-flavored milks was increased on holding them at refrigerated temperature. The samples had higher flavor scores 4 days after preparation than after 2 days.

THE EFFECT OF DDT, DIELDRIN, AND HEPTACHLOR ON THE GROWTH OF SELECTED BACTERIA

J. A. Collins and B. E. Langlois

Effect of chlorinated pesticides on bacteria in milk is of utmost importance if tolerances for these residues are to be established for dairy products. This study was made to determine the effect of DDT, dieldrin and heptachlor on the growth of Escherichia coli, Pseudomonas fluorescens and Staphylococcus aureus.

Procedure

Trypticase soy broth (TSB) and skimmilk were made up to contain 50 and 100 ppm of the desired pesticide. TSB and skimmilk without pesticide served as controls. The samples and controls were inoculated with the test bacteria and incubated for 7 days. Bacterial numbers were determined, using standard plate count agar immediately after inoculation and again after 1, 2, 4 and 7 days' incubation.

Results

Survival and multiplication of certain species of bacteria were affected in varying degrees by the presence of chlorinated insecticides in the culture media.

E. coli in TSB and skimmilk was not affected by any of the insecticides at the concentrations studied.

Both 50 and 100 ppm of DDT inhibited multiplication of Ps. fluorescens in TSB after 2 days; however this organism was not affected by dieldrin or heptachlor in TSB nor any of the pesticides in skimmilk.

The multiplication of S. aureus was not affected by dieldrin in TSB or in skimmilk containing any of the pesticides. DDT in TSB was inhibitory after 2 days. Heptachlor had a bactericidal effect. Further study showed that 1 ppm of heptachlor in TSB would cause inhibition and that the bactericidal effect became pronounced at 10 ppm heptachlor.

EFFECT OF CASEIN ON DECHLORINATION OF DDT AND INHIBITION OF GROWTH BY HEPTACHLOR

J. A. Collins and B. E. Langlois

Other work at this Station has indicated that skimmilk prevented the de-chlorination of DDT by E. coli and permitted the growth of S. aureus in the presence of heptachlor. This study was an attempt to determine why such reactions occurred in skimmilk and not in broth.

Procedure

Casein was obtained from fresh skimmilk and then fractionated into Alpha-, Beta- and Gamma- casein. Whole casein and the casein fractions were added to broth containing various levels of DDT or heptachlor.

The samples were inoculated with either E. coli or S. aureus and incubated at 37°C for 7 days.

The samples containing S. aureus and heptachlor were analyzed for growth every 2 hours the first day and then daily for the next 6 days. E. coli-DDT samples were analyzed for degradation products at daily intervals for 7 days.

Results

DDT was metabolized into several products by E. coli when grown in culture broth. Approximately 95% of the p,p'-isomer of DDT was metabolized after incubation at 37°C for 7 days. The presence of whole casein in the culture broth prevented the breakdown of DDT.

Growth of S. aureus was delayed for up to 2 days by as little as 1 ppm technical heptachlor in broth, and it was completely inhibited by 10 ppm.

Addition of 0.5% whole casein to broth containing 10 ppm technical heptachlor permitted growth after 2 days. Growth began without any delay when 3% whole casein was added.

The inhibition effect on the growth of S. aureus by heptachlor was reduced or eliminated by the presence of whole casein in the culture media. Further research indicated that all three casein fractions were needed to eliminate the inhibitory effect.

EFFECT OF 2,3,5-TRIPHENYL-TETRAZALOIM CHLORIDE (TTC) IN PLATING MEDIA ON THE ENUMERATION OF PSYCHROPHILES

O. Hampton and B. E. Langlois

The present official method for the enumeration of psychrophilic bacteria requires an incubation of 7°C for 10 days. Several methods using chemical inhibitors and higher incubation temperatures have been developed in an attempt to shorten the time required to determine psychrophiles. Most of these methods use TTC as a color indicator, either to change the color of a liquid media or to produce red-colored colonies on solid media.

Studies at this Station have shown numbers based on TTC-media were generally less than the standard method. Therefore, a study was initiated to determine the effect of TTC on the enumeration of psychrophiles. Temperature of incubation was studied as well.

Procedure

Standard plate count agar (SPC) containing 0 to 1% TTC was used for enumeration. Pasteurized milk samples were obtained from retail outlets and plated. The milk samples were replated after preliminary incubation (PI) at 12.8°C for 18 hr. All plating was in quadruplicate for SPC and each SPC-TTC concentration used. Incubation of one plate per set was at 7, 21, 25 and 32°C for 2 to 7 days, respectively.

Results

Sharp decreases in numbers were observed with increases in TTC level and also increases in incubation temperature of samples examined before PI. Plates incubated at 32°C showed a linear decrease in numbers up to 0.03% TTC where growth was completely inhibited. Plates incubated at 7°C were affected the least by TTC. Little change in numbers was observed up to 0.05% TTC, at which point, growth was increasingly inhibited until it was complete at 0.1%.

The effect of increasing levels of TTC on inhibition of growth was not so pronounced when the samples were examined after PI but followed the same general pattern as before PI. Complete inhibition occurred at 0.7% TTC at 7°C, 0.3% at 21°C, 0.5% at 25°C, and 0.1% for 32°C.

Correlations of results obtained with SPC and SPC-TTC and the various incubation temperatures were not very good except for SPC, and SPC-0.1% TTC at 7°C, and 21°C.

EFFECT OF COCOA POWDER ON THE GROWTH OF BACTERIA

B. E. Langlois and A. W. Rudnick

Chocolate milk has a fairly poor shelf life according to a recent study conducted by the authors. Little information is available concerning the microbiology

of chocolate milk or the ingredients used for its manufacture. This study was conducted to determine the role of cocoa powder in the growth of micro-organisms that may bring about the spoilage of chocolate milk.

Procedure

Cocoa powders used in the manufacture of chocolate milk were added to broth to give a cocoa concentration of 1.5%. Broth alone served as control. The samples were sterilized, cooled and inoculated in duplicate with Escherichia coli, Staphylococcus aureus, or Alcaligenes viscolactis. The samples were incubated at 7°C, 25°C, and 37°C.

Changes in bacterial numbers in both the samples and the controls were determined every 2 hours for the first 12 hours of incubation and daily for the next 4 days.

Results

E. coli

Cocoa powder apparently delayed the multiplication of E. coli for about 6 hours at an incubation temperature of 37°C, but then the organisms started to increase in numbers rapidly and at the end of 24-30 hours reached the same level of numbers as in the controls. Further change in numbers corresponded with change in the controls.

Cocoa powder appeared to have more of an effect on E. coli at 7°C incubation. The numbers in the cocoa powder samples decreased throughout the incubation period and were less than in the control.

S. aureus

S. aureus incubated at 37°C in the cocoa powder samples decreased in numbers for 12 hours then gradually increased until at the end of 48 hr multiplication leveled off. Maximum numbers in the samples were less than in the controls.

Cocoa powder appeared to have a bactericidal effect on S. aureus at 7°C, inasmuch as numbers declined almost linearly in the cocoa powder samples incubated at this temperature. Numbers after 2 days were less than half the number of S. aureus inoculated.

A. viscolactis

Cocoa powder was bactericidal to A. viscolactis at both 25 and 7°C. Numbers decreased rapidly in the samples when compared with those in the controls. The effect was even more pronounced in the samples incubated at 37°C. Numbers were quartered in 48 hr at 37°C and about halved at 7°C.

Cocoa powder used in the manufacture of chocolate milk appeared to inhibit the growth of some common spoilage bacteria. This effect is apparent at refrigerated temperatures as well as at the optimum temperature for the growth of the spoilage bacteria. The degree of the inhibition varies with the bacteria.

EFFECT OF BACILLUS SUBTILIS PROTEASE AND SODIUM TRIPOLYPHOSPHATE ON THE QUALITY OF AGED HAMS

James D. Kemp and Gregory Mayer

Production of dry cured hams is a sizeable industry and is increasing in Kentucky. Since some hams lack tenderness, methods are needed for improving this palatability trait. Commercial enzymes are used for tenderizing fresh meat. Phosphates are used to enhance the water-holding capacity of commercially cured pork. This project was devised to determine if a protease obtained from Bacillus subtilis microorganisms would enhance tenderness when used alone or in combination with sodium tripolyphosphate.

Procedure

Three groups of eight hams each were used. Group 1 was a dry-cured control. Group 2 was pumped with 4% of distilled water which contained protease so that each 100 lb of ham received 9.1 gm protease. Group 3 was pumped with 4% of distilled water which contained protease and tripolyphosphate so that each 100 lb of ham received 9.1 gm protease and 172.5 gm tripolyphosphate. Groups 2 and 3 received the same curing treatment as group 1. Hams were cured for 2 days per pound, held 30 days for salt equalization, then smoked and aged for 4 months at 75°F. Weight loss was determined during aging. After aging the hams were cut, scored for aroma, color, firmness and general appearance by a palatability panel for flavor, tenderness, saltiness, and overall satisfaction and evaluated for tenderness using a Warner-Bratzler shear.

Results

The control hams were uniform in color, firm and had a desirable general appearance. Hams treated with the protease were variable. Most had a dark red color. Five were slightly soft. One ham was spoiled and one had an acid aroma. Six of the hams were excellent in general appearance. The protease-phosphate hams were generally uniform in color but tended to be soft. Four had an acid aroma and four were variable in color.

Weight loss was significantly ($P < .05$) greater in the control hams through 2 months of aging. After 2 months the differences were not significant.

Tenderness as measured by the Warner-Bratzler shear was significantly improved by the protease ($P < .01$ for the semitendinosus and semimembranosus muscles and $P < .05$ for the biceps femoris muscle). The protease-phosphate group was intermediate in tenderness.

Palatability tests showed that flavor and overall satisfaction scores were significantly higher ($P < .01$) for controls than for either treated group. Tenderness again favored the protease group ($P < .05$). There was no significant difference in saltiness.

Summary

Hams were treated as controls, with protease, and with a combination of protease and tripolyphosphate. All were cured and aged alike.

Although the treated hams were more tender, the low scores for palatability traits indicate that neither the protease nor the combination of protease and tripolyphosphate is satisfactory for use in the production of aged hams.

EFFECTS OF AGING TEMPERATURE ON AGED HAM QUALITY

Thomas R. Lambuth and James D. Kemp

The desirable flavor and aroma of country style hams are developed by exposure to the natural warm summer temperatures. Because of the fluctuation of temperature from day to night and from different times in the summer, the quality of hams is not uniform and weight loss may reach as high as 30% during the aging period. New techniques are needed to produce a more uniform product, to reduce weight loss, and provide a more rapid turnover. This Station and others have worked with various procedures and have had varying results. The objectives of this study were to determine the optimum time, temperature and humidity for the rapid production of highly desirable country style hams.

Materials and Methods

Two groups of 20 hams each weighing about 8 kg were cured using the normal University of Kentucky procedure. After curing, excess salt was brushed from the hams and they were hung for 30 days for salt equalization. After soaking in warm water for 1 hour, the hams were hung to dry and then smoked for 18 to 24 hr at a smokehouse temperature of 38°C. The hams were randomly allotted into two equal groups. The first group was aged for 4 months at 24°C. The second group was aged with the first for 2 months at 24°C and then at 35°C for the final 2 months. The relative humidity was 60-65% for both groups. Hams were weighed when fresh, after smoking, and at monthly intervals during aging. Free fatty acid content was determined on subcutaneous and intermuscular fat on all hams. At the end of the aging period, the hams were observed for color, odor and appearance.

Two 1.3 cm center slices were cut from each ham and used in palatability studies. These slices were broiled in an electric oven for 7 min on one side, then broiled for 6 min on the other. The cooked slices were evaluated by a panel composed of seven members, and the hams were scored for flavor, saltiness, tenderness and overall satisfaction. Also a 2.5 cm center slice from each ham was cooked to 54°C, then turned and cooked to 76°C internal temperature and tenderness was measured by shearing 2.5 cm cores from the semitendinosus, semimembranosus and biceps femoris muscles on the Warner-Bratzler shear.

Data were analyzed by analysis of variance.

Results and Discussion

Weight loss increased during the aging period and was higher with the increased temperature. The group aged at 24°C for 4 months had an average weight

loss of 23.8% at the end of the aging period. The average weight loss of the group aged at 24°C for 2 months and at 35°C for 2 months was significantly ($P < .05$) higher at 25.6%.

The free fatty acid values were higher in the hams aged at the higher temperature indicating a higher degree of aging.

After cutting, the hams were observed for color, general appearance and aroma, with both groups being satisfactory and with little difference between groups.

The seven member panel found no significant difference in the flavor, saltiness or overall satisfaction for the two groups, but they did find the 24-35°C group to be significantly ($P < .05$) more tender than the 24°C group.

Cores from three different muscles were sheared on the Warner-Bratzler shear. The biceps femoris cores were significantly ($P < .05$) more tender as were the semitendinosus ($P < .01$) and semimembranosus, ($P < .01$) for the 24-35°C group. This tends to verify the panel findings that the high temperature aging increases tenderness.

Summary

Forty hams were randomly allotted to two equal groups. Both were given a normal cure, salt equalization and smoke. Group 1 was aged at 24°C for 4 months, group 2 was aged for 2 months at 24°C and 2 months at 35°C, and relative humidity was 60-65% for both groups. At the end of the trial the hams in group 2 had a higher percentage weight loss and were more tender to mechanical shear and organoleptic panel and had higher FFA values. There were no differences in flavor, saltiness or overall satisfaction. This indicates that a higher degree of aging and improved tenderness was achieved in the same amount of time at a higher temperature.

EFFECT OF FRESH HAM QUALITY AND AGING TEMPERATURE ON QUALITY OF AGED HAMS

John D. Crouse and James D. Kemp

Quality control has long been a major problem in the production of dry-cured, aged country hams. The problem arises, in part, from the lack of uniformity in the raw material and production techniques. To produce a highly desirable, uniform product commercially, the effects of quality and production techniques must be determined.

Procedure

Twenty-two high quality (scores of 3 or higher) and 22 low quality (scores of 1 or 2) hams were selected on the basis of the Wisconsin pork quality standards. Both groups were dry-cured, held 30 days for salt equalization, then smoked and aged for 56 days at 24°C and 60-65% relative humidity. After 56 days of aging, both groups were randomly divided into two groups (high quality, A and B; low quality, C and D). Groups A and C were aged an additional 56 days at 35°C and 60-65% relative humidity, while groups B and D were aged for the same length of time at 24°C.

Fresh lean samples were analyzed for moisture, protein, ether extract and pH values. Weight losses were recorded at regular intervals during processing. After aging, the hams were sliced and observed for soundness, color and aroma. Flavor, saltiness and tenderness evaluations were made by a palatability panel. Tenderness was also tested by a Warner-Bratzler shear. Cured lean samples were analyzed for water, ether extract and protein. Cured ham intermuscular and subcutaneous fat samples were analyzed for free fatty acid (FFA) values.

Results

Proximate analysis of lean from the fresh hams showed that the percentage protein was lower ($P < .01$) and ether extract was higher ($P < .01$) in the high quality hams. The pH of the gluteus medius muscle was higher ($P < .01$) in the high quality hams; however, no significant difference was noted in the gluteus accessorius muscle.

Table 1 summarizes the data. The total percentage of shrinkage, after the initial 56 days of aging, was higher ($P < .05$) in the low quality group. After 4 months' aging, the effects of quality and temperature were significant ($P < .01$). Group C shrank more than groups B ($P < .01$), A ($P < .05$) and D ($P < .05$). Tenderness tested by the Warner-Bratzler shear, on the semimembranosus and semitendinosus muscles, showed group B was less tender ($P < .01$) than groups C, D and A. The biceps femoris of group B was less tender than groups C ($P < .01$) and A ($P < .05$). Sensory panel members detected no significant differences in saltiness, flavor and overall satisfaction; however the panel did indicate that the low quality hams were more tender than the high quality hams. The subcutaneous fat of group C had more free fatty acids than that of groups B ($P < .01$) and A ($P < .05$).

Table 1. — Characteristics of Cured Hams of Different Quality and Aging Temperature^{1/}

	Group			
	High Quality		Low Quality	
	A	B	C	D
Temp., °C	35°	24°	35°	24°
Wt. loss %				
3 mo.	24.99	22.83 ^d	26.65 ^c	25.10
4 mo.	27.35 ^b	25.04 ^d	30.58 ^a _c	27.24 ^b
Mean Palatability scores				
Flavor	6.2	6.7	6.2	5.8
Saltiness	6.7	6.9	6.9	6.7
Tenderness	7.3	7.1 ^b	7.5 ^a	7.5 ^a
Overall satisfaction	6.3	6.7	6.1	6.3
Mean Shear Force Values ^{2/}				
<u>Semimembranosus</u>	4.00 ^d	8.35	3.86	3.76
<u>Semitendinosus</u>	5.81 ^d	8.66 ^c	5.78 ^d	5.22 ^d
<u>Biceps femoris</u>	7.80 ^b	9.64 ^a _c	7.21 ^d	8.35 ^d
Proximate Analysis of Lean				
Protein	25.77	23.58 ^b	26.40 ^a	24.94
Ether Extract	5.98 ^b	5.12	4.17 ^a	3.62 ^c
Moisture	56.39 ^d	58.11	55.71	58.40
Mean FFA values				
Intermuscular	7.51	6.64	8.38	7.34
Subcutaneous	9.09 ^b	8.06 ^d	11.96 ^a _c	10.16

^{1/}Numbers in same horizontal row with same superscripts do not differ significantly, $P < .05$.

^{2/}Kg. force required to shear a 2.54 cm. core.

EFFECTS OF SALT, MOISTURE AND AGING TIME ON THE VIABILITY OF TRICHINELLA SPIRALIS IN DRY-CURED HAMS

John D. Crouse, James D. Kemp and J. M. Edney*

Recent reports in the United States have shown that the incidence of trichinosis has declined in the past 10 years. This decline can be partially attributed to federal meat inspection regulations for ready-to-eat pork products and consumer education concerning trichinosis. Commercially cured hams must be heat treated to destroy viable trichinae. Dry-cured hams, which are produced not to be eaten without cooking by the consumer, are not heat treated but are subjected to conditions of curing and smoking that are not conducive to a highly acceptable product. This project was undertaken to evaluate a method of producing high quality country-cured hams and shoulders, free from disease-producing trichinae, from hogs weighing up to 280 lb and to learn if observations of heavier hams and shoulders would parallel previous observations with cuts from hogs weighing approximately 200 lb as reported in the 1967 Animal Science Research Reports.

Procedure

Twenty-eight pigs weighing approximately 100 lb were dosed with excysted trichina larvae, grown to approximately 280 lb, and slaughtered. The hams and shoulders were removed and examined microscopically for trichina larvae. Twenty-four of the more heavily infected hams and 24 of the more heavily infected shoulders were then selected for further studies.

Cores were taken from 8 hams and 8 shoulders after salt equalization, after smoking and at weekly intervals during aging. Additional samples were taken at these periods, digested in a pepsin-HCl solution and microscopically examined for viable trichina larvae. This sampling procedure was followed until no viable larvae were found. At this time, similar samples were force fed to rats for 5 days. After feeding the rats a commercial ration for an additional 8 weeks, they were sacrificed and their carcasses examined for trichina larvae to verify microscopic observations.

Results

There was no appreciable change in the number of viable larvae after salt equalization and smoking. However, after 1 week of aging approximately 50% of the larvae had lost their viability. After 2 weeks' aging, 7 of the 8 shoulders examined had no viable larvae. After 3 and 4 weeks' aging no viable larvae were found, and a marked reduction in total numbers was also noted. Similar samples from these three periods were fed to rats, and no trichina larvae were recovered. The average salt concentration of the lean for the shoulders after 2 weeks' aging, which appears to have been the critical length of time, was 4.5%.

Results with hams were quite similar. There was a marked reduction in total numbers and no viable larvae after 3 weeks' aging. The average salt concentrations of the lean at this period was 3.3%. Examinations were also made at 4 and 5 weeks of aging. Samples from these three periods were force fed to rats which showed no infection when sacrificed and examined.

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Summary

Trichinae-free country-style hams and shoulders may be produced by curing normally, holding for one month for salt equalization, then smoking and aging 3 to 4 weeks at 75°F.

EFFECT OF FATNESS AND FRESH PORK QUALITY ON YIELD AND QUALITY OF HAM AND BACON

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

Hams and bellies from 74 hogs shown at the 1968 Louisville Barrow Show were selected on the basis of fatness and quality as shown in Table 1.

Table 1. — Characteristics of Hams and Bellies

No.	Backfat, in.	Qual. Score ^{a/}	Ave Wt Hams, lb	Ave Wt Bellies, lb
20	Under 1.3	1 to 2	18.4	10.0
20	Under 1.3	2+	18.3	9.8
20	Under 1.3	3 to 4	17.5	10.5
20	1.3 - 1.6	1 to 2	18.7	10.1
20	1.3 - 1.6	2+	17.8	10.5
20	1.3 - 1.6	3 to 4	17.7	10.4
14	Over 1.6	2 to 2+	17.8	11.9
14	Over 1.6	3 to 4	16.9	11.4

^{a/}Based on Univ. of Wisconsin quality standards

Procedure

Normal processing procedures of a cooperating packing plant^{1/} were used.

Hams were weighed, pumped with an automatic pumping machine with approximately 10 percent of fresh weight of a standard pickle, allowed to cure for 3 days, smoked overnight, chilled for approximately 24 hr and weighed. Yields were figured on fresh weight and chilled smoked weight.

Bacons were weighed, skinned, re-weighed, automatically pumped at approximately 8% of fresh weight with a standard pickle, cured for 3 days, smoked overnight, chilled, weighed, held an additional 24 hr, pressed, weighed, and sliced. The sliced bacon was graded No. 1, 2, 3 and other. The other included end slices and scrap and was determined by difference.

At least six slices from one bacon from each hog was obtained from the second full pound from the flank end. These slices were vacuumed sealed and returned to the University of Kentucky Meat Laboratory.

^{1/}Fischer Packing Company, Louisville, Ky.

The sliced uncooked bacon was subjectively evaluated for lean-fat ratio, color and general appearance by a seven member panel. Three slices were weighed and then broiled in a household type oven. The slices were placed 14 cm from the heating element, broiled for $2\frac{1}{2}$ min, turned, and broiled for 2 min. The slices were then blotted with paper towels, weighed and the yield of cooked bacon was calculated. The cooked slices were evaluated by the panel for color, general appearance and flavor and tenderness. Three slices from each bacon were dissected into fat and lean and the percentage of each was calculated.

Results and Discussion

There was a significant ($P < .01$) difference in yield of ham and smoked bacon owing mainly to quality. As quality improved the yield of ham increased in all three fatness groups and the yield of smoked bacon increased in the two thinner groups, with little difference being due to fatness except there was a higher yield of skinned bellies and smoked bacon in the fatter group due to a lower percent of skin. Table 2 shows the results.

The percentage of number 1 bacon increased as quality improved in all fatness groups, with little effect being due to fatness. The percentage of other grades was somewhat variable. The fat group was still lean enough to make number 1 bacon and the lean groups were thick enough for number 1 bacon. This may indicate that there is a wide range in fatness within a grade of bacon.

Table 2. — Yields of Hams and Bacon

Ave Backfat in.	Quality Score	Smoked Ham %	Skinned Belly %	Smoked Bacon %	Bacon grade and yield %			
					No. 1	No. 2	No. 3	Other
Under 1.3	1 to 2	92.7	83.2	78.2	70.2	5.8	5.1	19.0
Under 1.3	2+	93.7	84.1	79.5	77.3	2.6	1.1	19.0
Under 1.3	3 to 4-	96.6	85.4	82.3	79.8	2.9	3.5	13.7
1.3 - 1.6	1 to 2	92.3	83.5	78.5	66.5	8.9	3.4	21.2
1.3 - 1.6	2+	95.1	85.0	79.8	70.2	10.3	5.0	14.6
1.3 - 1.6	3 to 4-	96.1	85.3	82.0	75.8	7.6	1.9	14.7
Over 1.6	2 to 2+	93.1	87.0	83.9	71.5	9.7	1.7	7.1
Over 1.6	3 to 4	95.3	87.0	84.1	77.7	7.4	2.2	12.6

A summary of the subjective evaluation of bacon is shown in Table 3. The only major difference in appearance of the uncooked bacon was in the lean-fat ratio. The leaner two groups had almost identical scores, while the fat group had a lower score. Color and general appearance scores were similar. In the cooked bacon the average scores were similar in all groups with the averages being in the very good to excellent category for most bacon. A few slices were graded lower for lacking uniformity in color or shape, and being slightly off in color. However, there was no apparent relationships between the individual low grades and fresh characteristics.

Table 3. — Summary of Subjective Evaluation of Bacon

Backfat in.	Qual. Score	Lean-fat ^{a/} ratio	Uncooked			Cooked		
			Color ^{b/}	Gen Appear ^{c/}	Color ^{c/}	Gen Appear ^{c/}	Flavor ^{c/}	Tend ^{c/}
Under 1.3	1 to 2	4.3	3.7	3.8	4.4	4.4	4.5	4.3
	2+	4.3	3.8	3.9	4.4	4.1	4.4	4.2
	3 to 4-	4.2	4.3	4.4	4.5	4.5	4.5	4.5
1.3 to 1.6	1 to 2	4.4	4.1	4.0	4.1	4.3	4.2	4.3
	2+	4.5	4.1	4.2	4.5	4.4	4.5	4.4
	3 to 4-	4.0	4.0	3.7	4.7	4.5	4.5	4.4
Over 1.6	2 to 2+	3.6	3.9	4.0	4.1	4.1	4.2	4.4
	3 to 4	3.7	4.0	4.0	4.2	4.3	4.5	4.4

^{a/}1 = fat; 2 = slightly fat; 3 = average; 4 = lean; 5 = very lean

^{b/}1 = dark; 2 = slightly dark; 3 = average; 4 = bright and uniform;
5 = very bright and uniform

^{c/}1 = poor; 2 = fair; 3 = good; 4 = very good; 5 = excellent

The results of physical separation and yields of cooked bacon are shown in Table 4.

Table 4. — Summary of Objective Evaluation of Bacon

Backfat, in.	Qual Score	Uncooked		Yield of cooked bacon %
		Lean %	Fat %	
Under 1.3	1 to 2	43.3	56.7	34.4
Under 1.3	2+	41.9	58.1	34.0
Under 1.3	3 to 4-	42.4	57.6	32.0
1.3 to 1.6	1 to 2	44.8	55.2	33.5
1.3 to 1.6	2+	42.8	57.2	35.9
1.3 to 1.6	3 to 4-	39.6	60.4	30.7
Over 1.6	2 to 2+	39.1	60.9	30.9
Over 1.6	3 to 4	34.5	65.5	32.3

There was little difference in percentage fat and lean in the thin backfat group. In the second fatness group, the higher quality bacon tended to have less lean. In the fatter group this was again noted. Backfat affected leanness, but there appeared to be a relationship between quality and leanness.

Differences in yield of cooked bacon were less than might have been expected although the average yield for the fatter group was slightly less. There was little relationship between cooked bacon yield and quality.

Summary

Quality of fresh hams affected the yield of cured smoked ham. As quality improved, yield improved in the three fatness groups studied. This was also true for bacon but to a lesser degree. Fatness had little effect on yield of ham but the fatter bacon tended to yield a slightly higher percentage of smoked slab bacon, owing mainly to the percentage of skin.

The percentage of number 1 bacon increased as the quality improved. There was, however, very little effect on yield owing to fatness.

Subjective evaluation of uncooked and cooked bacon showed few differences except for a lower lean fat ratio in the fatter group. Panel scores for cooked bacon were similar for all traits. Lean yield was similar up to 1.6 in. of backfat and slightly less in the fatter group. Yield of cooked bacon was not affected appreciably by quality but was decreased slightly in the fatter bacon.

CARCASS TRAITS OF LAMBS OF DIFFERENT GAINING ABILITY AND SLAUGHTER WEIGHTS

Thomas R. Lambuth, James D. Kemp and H. A. Glimp

There is an apparent trend by retailers to demand heavier, meatier and trimmer lamb carcasses. Leanness of cuts ranks high on the consumer response list. Several investigators, however, have found a high positive relationship between weight of lamb and amount of carcass fat. Very little work has been reported concerning the effect of growth rate on carcass fat. However, workers have found low positive associations between rate of gain and amount of muscle and bone in a carcass and a negative association with amount of fat. This experiment was designed to determine the effect of slaughter weight and rate of gain on carcass composition; the relationship between various external and internal carcass measurements, and the composition of various cuts and the composition of the carcass.

Materials and Methods

Seventy-two Hampshire x blackface lambs were selected from approximately 120 wether lambs which were weaned at 18 kg and grown to 27 kg. The lambs were then assigned to a 2 x 3 factorial arrangement of treatments in which the fastest-gaining 36 lambs were designated "fast-gainers" and the slowest-gaining 36 were designated as "slow-gainers." These groups were then randomly assigned to groups of 12 lambs each, fed a standard growing and finishing ration and slaughtered at 36, 45 and 54 kg, respectively. After a 48-hr chill at 20°C the lambs were graded, external and internal carcass measurements were taken, and the lambs were cut into wholesale cuts, retail cuts and edible portion. The leg and rack were dissected into fat, muscle and bone. Samples of the 1. dorsi and semitendinosus muscles were analyzed for moisture, protein and ether extract. The data were analyzed by analysis

of variance. In addition, simple correlation coefficients were calculated on a within-weight group basis.

Results and Discussion

The percent total retail cuts decreased significantly ($P < .01$) as slaughter weight increased (36 kg, 87.0%; 45 kg, 84.4%; 54 kg, 81.3%). The percent total edible portion also decreased significantly ($P < .01$) as slaughter weight increased (36 kg, 66.3%; 45 kg, 63.9%; 54 kg, 59.3%). The percent total fat trim moved in the opposite direction. As slaughter weight increased, percent total fat trim increased significantly ($P < .01$) (36 kg, 15.0%; 45 kg, 18.9%; 54 kg, 25.6%). The percent total bone decreased significantly ($P < .01$) as slaughter weight increased (36 kg, 18.5%; 45 kg, 17.1%; 54 kg, 15.0%).

The rate of gain by the lambs from 27 kg to their respective slaughter weights had no effect on the percent total retail cuts or percent total edible portion. The slower gaining lambs had a significantly ($P < .05$) higher percent total fat trim (20.7%) than the fast-gaining group (18.9%). The fast-gaining group had a significantly ($P < .01$) higher percent total bone (17.3%) than the slow-gaining group (16.4%). There also was a significant ($P < .05$) effect of the combined action of slaughter weight and rate of gain on percent total fat trim and percent total bone.

The retail leg and shoulder as a percentage of the carcass decreased as slaughter weight increased while the retail loin and rack percentage remained unchanged. This suggests that the increased weight of the loin and rack at increased slaughter weight is largely fat trim.

The most accurate internal and external carcass measurements of fatness were the minimum width behind the scapulae, fat over the l. dorsi, fat over the spinous process and fat over the lower rib (the latter three taken at the twelfth rib). All of these measurements increased with increased carcass fatness.

There was very little relationship between area of the l. dorsi measured at the twelfth rib and meatiness in the carcass.

There was no relationship found between carcass grade and carcass composition but lambs were much alike and grades only ranged from average Choice to high Prime.

Significant positive correlations were found between percent kidney and pelvic fat and percent total fat trim at all slaughter weights.

The two cuts whose composition was most accurate in predicting the percent carcass retail cuts, edible portion and muscle were the leg and rack. The loin and leg were the best predictors of carcass fat. The percent bone in the carcass was more highly correlated with bone in the shoulder than with bone in the leg. Considering the relative value of the leg as a predictor of muscle, fat and bone of the carcass, and ease of removal and handling, the leg was the single best all-around cut for predicting carcass composition.

At the higher slaughter weights the percent water decreased and percent ether extract increased in the l. dorsi and semitendinosus muscles as carcass fat increased. There was little relationship between the crude protein of these two muscles and carcass composition.

Summary

Lambs of different gaining ability were slaughtered at 36, 45 and 54 kg. As slaughter weight increased carcass fatness increased and retail cuts, edible portion and bone decreased. As rate of gain increased carcass fat decreased, bone increased and retail cuts, edible portion and muscle were unchanged. Increased weight of the rack and loin at higher weights was mostly fat. Fat depth at the twelfth rib, percent kidney and pelvic fat, and minimum width behind scapulae were good predictors of carcass fat. Ribeye area was of little value in predicting carcass muscle. There was no significant relationship between grade and carcass composition in the average Choice to high Prime range. Although the composition of several wholesale cuts could be used to predict the composition of the carcass, the leg was the most valuable cut for this purpose.

HERITABILITY ESTIMATES OF SOME LAMB CARCASS TRAITS

Robert H. Smith, James D. Kemp, W. G. Moody and L. V. Cundiff

Greater emphasis is being placed on growth rate and carcass trimness and muscling. This project was designed to study the influence of sires upon the gaining ability and carcass characteristics of lambs.

Procedure

During the years 1958 through 1965, carcass data were obtained from 504 lambs, the progeny of 21 different sires and crossbred western ewes. Both ewes and wethers were used in the study as well as both singles and twins. Of the different sires, 9 were Hampshire and 12 were Southdown. The sires were selected by their average daily gain on an 149-day feeding trial, and they were allowed to randomly mate to the ewes. The % fat and lean from the leg and rack were obtained by physical separation. The data were analyzed by least squares analysis of variance.

Results

The traits studied and their estimates of heritability are given in the following table.

Table 1. — Heritability Estimates

Trait	Heritability Estimate	Standard Error
USDA carcass grade	10.08%	0.17
Carcass weight per day of age, lb	16.03	.20
% fat of the leg	28.50	.15
% lean of the leg	31.81	.27
% fat of the rack	18.36	.39
% lean of the rack	31.31	.58
Backfat thickness	27.41	.52
Loin eye area	11.57	.29
Loin eye area/45 lb carcass	52.59	.88

While the heritability estimates are near the expected value, their respective standard errors are quite large. This is due first to the small number of sires used in the project, and secondly to the lack of variation among the sires. The sires were selected by their post-weaning average daily gains with a range of 0.08 to 0.78 lb per day; therefore, sire variation was present. However, all of the rams were considered to be above average in conformation, and there was little variation in this respect.

The carcass grade can be considered as an indication of the carcass quality, and the heritability estimate of 10% is similar to other reported estimates. There was very little variation within the lambs as fewer than 1 percent were in the good grade. Carcass weight per day of age indicates the growth rate of the lamb, and the heritability estimate of 16% indicates that selection for rate of growth would be effective.

The percent lean of the leg and of the rack, loin eye area, and loin eye area per 45 lb of carcass are indicators of muscling. The traits that indicate carcass trimness are percent fat of the leg and rack, and backfat thickness. The heritability estimates of these traits suggest that selection in favor of muscling and against fat is effective in improving muscling and trimness.

EFFECTS OF RATE OF GAIN AND WEIGHT AT SLAUGHTER ON CERTAIN QUALITY CHARACTERISTICS OF LAMBS

Doris Tichenor, James D. Kemp and W. G. Moody

A few research studies have given information on the eating quality of cooked lamb or data on cooking losses and yield of edible meat. However, the influence of age of animals and preslaughter nutrition on quality characteristics of lamb have not been thoroughly investigated. Although it is generally agreed that carcass fat is an important factor in determining carcass grade, reports concerning the effect of fat on lamb palatability are conflicting. This study was designed to determine the influence of rate of gain and weight at slaughter on certain quality characteristics of lamb.

Procedure

The experimental design and carcass handling techniques were as previously reported (Lambuth, Kemp and Glimp; this volume). A rack from each of the 72 lambs was used for taste panel evaluation. All cuts were wrapped in moisture-vapor-proof paper and stored at -18°C until needed. Percentages of loss owing to cooking were based on the raw, trimmed weight of the thawed cut.

The racks were roasted at 163°C to an internal temperature of 85°C in groups of four per session. After cooking, 1/4-inch slices from the longissimus dorsi were served hot to a six-member panel experienced in judging meats. A rating score ranging from 1 (very poor) to 10 (excellent) was assigned to each sample by the panel members for the following characteristics: flavor, juiciness, tenderness and general acceptability.

After cooling, two 1/2-inch cores taken from l. dorsi were used for Warner-Bratzler shear determinations.

Results

There was little difference among flavor scores for fast- and slow-gaining lambs, or among the three slaughter weights (Table 1). All flavor scores were between 7.9 and 8.1, which is a rating of "good" on the 10-point scale.

Table 1. — Sensory Evaluation of Roast Lamb^{a/}

	Weight at Slaughter					
	36 kg		45 kg		54 kg	
	Rate of Gain		Rate of Gain		Rate of Gain	
	Slow	Fast	Slow	Fast	Slow	Fast
Flavor score	8.1	8.0	8.0	8.0	7.9	7.9
Juiciness score	7.7	7.3	7.3	7.5	7.6	7.3
Tenderness score	7.2	6.9	7.5	7.8	6.9	7.7
General acceptability	7.6	7.3	7.6	7.7	7.7	7.6

^{a/} Each value is an average of 12 judgments on each of 12 samples-- a total of 144 judgments

Scores for juiciness varied between fast and slow rates of gain and among light, medium and heavy slaughter weights, but no clear-cut superiority was attributable to any of these groups.

Meat from the heavier lambs was judged more tender than that from the lighter animals. Tenderness scores were lowest for samples from fast-gaining lambs slaughtered at 36 kg.

All samples were judged approximately equal in general acceptability, but the fast-gaining, lightweight lambs received slightly lower scores than the other groups.

The palatability data indicate that these aspects of quality are not appreciably affected by variation in slaughter weights from 36 to 54 kg, or by gaining ability of the animals.

Weight loss in cooking (Table 2) was slightly higher for racks from slow-gaining lambs slaughtered at 54 kg. Values for percentage of shrinkage were very similar for all of the other groups.

Table 2. — Percent Shrinkage of Roast Lamb

Rate of Gain	Weight at Slaughter		
	36 kg	45 kg	54 kg
Slow	21.1	22.1	25.2
Fast	21.6	21.5	22.0

Warner-Bratzler shear values (Table 3) were highest for the fast-gaining, lightweight group, which also were assigned the lowest tenderness scores. Lowest shear values were associated with the heavyweight group.

Table 3. — Warner-Bratzler Shear Values^{a/}
of Roast Lamb

Rate of Gain	Weight at Slaughter		
	36 kg	45 kg	54 kg
Slow	12.5	14.5	10.6
Fast	15.5	12.6	11.0

^{a/} Lb force to shear 1/2-inch cores

GENETICS AND PHYSIOLOGY SECTION

SELECTION FOR OXYGEN CONSUMPTION OF THREE-WEEK-OLD CHICKENS

D. W. MacLaury and T. H. Johnson

Performance traits differ between established strains of chickens, indicating inherited differences, possibly in metabolic rate. A trial, in which birds were selected for high and low rates of oxygen consumption at 3 weeks of age, has resulted in two strains in which unselected progeny of selected parents differ significantly in their oxygen consumption.

The average rate for 187 females of the high-oxygen line was 3.10 ml of oxygen per 100 gm of body weight per minute. The rate for 202 males of the same line was 2.90. In the low-oxygen line 141 females averaged 2.53 and 156 males 2.43 ml. Differences between lines were significant, while differences between sexes within lines were not.

MEASUREMENT AND SELECTION OF ECONOMICALLY IMPORTANT TRAITS IN BEEF CATTLE

F. A. Thrift, N. W. Bradley, J. D. Kemp and J. R. Overfield

During recent years, considerable effort has been directed toward increasing the number of females in the breeding herd. Each year a large number of heifers were retained in order to increase the herd size as rapidly as possible. At the present time, there are currently 230 Hereford females of breeding age located at the U. K. West Kentucky Substation at Princeton.

During April, May and June of 1967, 230 females of varying ages were exposed to 12 bulls, 4 of which were bred artificially. Twenty-nine of these 230 cows were culled from the herd during the fall of 1967 primarily on the basis of their poor reproductive performance. Of the remaining 201 females, 183 calved during the 1968 calving season (January, February, March), and there are currently 161 live calves in the herd.

There were 151 calves (73 bulls and 78 heifers) reared that were born during the 1967 calving season, and these were weaned at an average age of 216 days. Approximately 10 days after weaning, the bulls were placed on a 150-day postweaning performance test and received a full-feed of the following ration:

	<u>Pounds/Ton</u>
Ground shelled corn	850
Ground corn cobs	650
Molasses	200
Alfalfa leaf meal	50
Soybean meal (44%)	235
Dicalcium phosphate	5
Salt	10
Vitamin A	2,000,000 I. U.

The heifers remained on pasture and received enough corn silage and supplemental grain to gain approximately 1.0-1.25 pounds per day.

The postweaning feeding test for the bulls was concluded on Feb. 27, 1968, and 10 (6 sires represented) of the 73 bulls were selected on the basis of their growth performance as potential herd sires for future use in the herd. At the same time the bulls were weighed off of the postweaning test, the heifers were also weighed and their performance during the winter evaluated. Of the 78 heifers available to select from, 40 (9 sires represented) were retained as replacements. A comparison of the performance of the selected bulls and heifers with the performance of all bulls and heifers, respectively, is presented in Table 1.

The information presented in Table 1 illustrates the greater selection pressure that can be directed toward sire selection as contrasted to that for female selection, since fewer sires need be selected. In most herds, a large number of female replacements are required to maintain reproductive performance. Thus, the selection pressure is usually less for heifers than for bulls, since the intensity of selection is directly related to the number selected.

With the type of information presented in Table 1 available, one can predict the expected response in terms of progeny performance if selections are made among the various bulls for a particular trait. Suppose that two of the 73 bulls are to be selected and it is desired to select these bulls on the basis of their adjusted 365-day weight. For illustration purposes, it will be assumed that bull A and bull B have adjusted 365-day weights of 1,000 and 900 lb, respectively. The difference between the 365-day weight of bull A and the average weight of all bulls (806 lb) is 194 pounds. If the heritability of 365-day weight is 60%, then bull A's progeny would be expected to average about 58 lb above the herd average at 365 days of age ($\frac{1}{2} \times 194 \times 60\% = 58.2$). Similar computations for bull B reveal that his progeny would be expected to average about 28 lb above the herd average. Thus, a comparison of the expected progeny performance for the two sires suggests the advantage to be gained in terms of progeny performance by selection of a bull with superior performance as compared with one with average performance.

After the 10 bulls were selected, all remaining bulls were slaughtered so carcass data could be obtained. The information on these 63 bulls is summarized according to sire in Table 2. These data suggest very little difference in the various carcass traits for the progeny from the different sires. Most of the progeny had a minimum amount of fat covering over the 12th rib, and all had high cutability scores. These results were to be expected with cattle as young as these were (394 days). If they had been fed for a longer period of time, perhaps more or greater differences would have been apparent for the various sire groups. All of these bulls were still in what would be considered an active stage of growth.

Table 1. — Comparison of the Growth Data of Selected Bulls (SB) and Heifers (SH) with all Bulls (AB) and Heifers (AH), respectively (1967 calves).

	No.	Prewaning		Postweaning		
		Adj. ADG ^a /	205-Day Wt. ^a /	ADG	WDA	365-Day Adj. Wt. ^a /
Selected bulls (SB)	10	1.98	483	2.63	2.49	928
All bulls (AB)	73	1.65	408	2.36	2.16	806
Difference (SB-AB)		+.33	+75	+.27	+.33	+122
Selected heifers (SH)	40	1.72	424	1.21	1.61	597
All heifers (AH)	78	1.57	392	1.08	1.47	546
Difference (SH-AH)		+.15	+32	+.13	+.14	+51

^a/ Adjusted for age of dam.

Table 2. — Comparison of Various Carcass Traits of Progeny from Several Sires

Sire	No. Progeny	Slaughter		Carcass		Fat ^a / thick.	Rib eye-area	% ^b / Cutability
		Age	Wt	Wt	Wt/day/age			
RH1	3	451	913	548	1.21	0.32	11.3	51.8
Z6	6	409	800	482	1.18	.26	10.4	52.1
Z44	9	389	788	469	1.20	.23	10.4	52.4
PZ4	7	380	709	421	1.11	.22	10.0	52.6
A41	5	378	765	469	1.24	.29	10.6	52.2
BVH	3	388	793	476	1.22	.23	10.4	52.2
C30	9	397	814	480	1.21	.25	9.9	51.8
HRH14	1	353	790	474	1.34	.15	10.7	53.3
HH6	1	384	864	557	1.45	.25	11.2	52.3
PZ8	9	387	800	487	1.26	.27	11.2	52.5
TR8	10	402	842	513	1.28	.28	10.5	51.9

^a/ Measured between 12 and 13th rib.

^b/ Estimated boneless, trimmed retail cuts.

AN EVALUATION OF SIX CHEMICAL TESTS FOR PREGNANCY IN CATTLE

F. S. Button, Jr. and D. Olds

Useful hormonal tests for pregnancy have been available for women and mares for nearly 40 years. Such tests have not been applicable to cattle. However, during the past 10 years, several rather simple chemical tests on urine, mucus, or milk have been reported in foreign journals (mostly Russian) as being reliable for pregnancy diagnosis in cattle. These tests included: (1) boiling a drop of mucus in distilled water

for 15 minutes and looking for the development of a cloudy color which was supposed to indicate pregnancy; (2) boiling a drop of mucus in 10 or 25% sodium hydroxide and looking for a brownish color, which was considered indicative of pregnancy; (3) estimating the specific gravity of mucus by placing a drop in a copper sulfate solution having a specific gravity of 1.008; if the cow is pregnant, the mucus is supposed to sink below the surface; (4) adding Lugol's solution, drop by drop, to a 5 ml sample of urine until a deep yellow color is developed; then 1 ml of concentrated sulfuric acid is added to the bottom of the test tube; a pink-purple band at the interface is considered indicative of pregnancy; (5) subjecting milk or a cream layer of milk to ultraviolet light and looking for a pale yellow color as opposed to dark lemon; in the case of cream layers, the color for pregnancy should be yellow or yellowish-blue as opposed to dirty violet; (6) adding 5-10 drops of a 1% barium chloride to 20 ml urine samples and looking for a white precipitate within 3 minutes, which indicates non-pregnancy.

When these tests were applied to 192 urine samples, 72 mucus samples, and 30 milk samples, it was found that only 53.4% of the results were accurate when 51.2% of the samples were from pregnant cows. Some of the tests would appear to be accurate if applied only to pregnant or to open cows, since virtually all cows responded to the tests in the same way.

A SURVEY OF DAIRY FARMERS CONCERNING BREEDING AND MANAGEMENT PRACTICES

T. A. Curtsinger, D. Olds, and O. W. Deaton

Data were obtained by interviewing 100 farmers in 3 counties who sold milk from at least 10 cows. Of these farmers, 47% used artificial insemination in their herds and 20% were members of a D.H.I.A. Half of the farm operators were tenants. The average farm was 205 acres, and 25.4 cows were being milked. The farmers averaged 43.9 years of age and had had 9.7 years of schooling; 13% had off-the-farm jobs.

About 84% of the dairymen relied on their artificial insemination technician to decide which sire to use. About 60% could name at least one sire being used. Only 13% knew the sire's predicted difference, but 23.8% knew his type classification. The sire named most often was a highly regarded sire at the top of page one in the catalog.

Seventy-two percent of the dairymen used beef sires on heifers (89% natural service).

While 56% of the dairymen were primarily interested in improving the production of their herds, 14% preferred to improve the fat test; others were interested in udder size, body size, or type.

There was a correlation coefficient of 0.36 between gross farm income and number of years completed in high school.

THE EFFECT OF IRRIGATION AND NITROGEN FERTILIZATION ON THE NITRATE CONTENT OF SUDEX FORAGE

R. C. Bennett, D. Olds, and D. M. Seath

A field of sudex was divided into 24 plots, and half of these were irrigated at 10- to 14-day intervals. Four of the irrigated plots and four of the non-irrigated plots were given nitrogen applications of 60, 120, or 240 lb of nitrogen per acre. Half of the fertilizer was applied at the time of seeding and the other half was applied in equal portions after the first and second cuttings which were made on July 4 and August 18.

The irrigated plots averaged 3.3% KNO_3 in the sudex dry matter as compared with 2.3% for the non-irrigated plots. The application of 60, 120, and 240 lb of nitrogen per acre resulted in mean levels of KNO_3 in the forage of 2.1%, 2.9% and 3.5%, respectively. The first, second, and third cuttings averaged 4.3%, 2.2% and 1.9% KNO_3 respectively.

The water and fertilizer treatments had only small effects on yield, which was about 3,500 lb per acre at each cutting (the first cutting was the highest). In general, high levels of nitrate in the sudex forage were associated with high yield, low dry matter, high protein, and low fiber.

EFFECT OF HERD SIZE ON FERTILITY AND DELAYED RETURNS

D. Olds and O. W. Deaton

Data from 505 dairy herds averaging 31.8 ± 9.5 cows bred (range 20 to 111) each year for 2 years indicated that fertility declined about 0.08 percentage units for each increase of one cow in herd size. The herds averaged 11.7 returns, of which 45.2% were after periods of 26 days or more since the first service. The correlation coefficient between number bred and percentage of delayed returns was 0.55 ($P < 0.01$), and the regression coefficient indicated that each additional cow bred resulted in 0.96 percentage units more delayed returns.

THE RELATIONSHIP BETWEEN NITRATE CONTENT OF FORAGES AND DAIRY HERD FERTILITY

R. C. Bennett, D. Olds, and D. M. Seath

Pasture, hay, and silage samples were obtained from 58 herds in 10 artificial insemination locals. Nitrate levels were determined as the percentage of KNO_3 equivalent in the dry matter. Herd fertility was based on the percentage of 2-12 months non-returns from first service. A summary of the results is shown in Table 1.

Table 1. — Herd Fertility vs. Nitrate Level of Forages

Herd Fertility	No. Bred	% Non>Returns	% KNO_3
Low	964	46.5	0.188
Average	824	64.2	0.140
High	100	87.5	0.092

The correlation coefficient between the mean KNO_3 content of forages and herd fertility was -0.172, which was not statistically significant. However, the regression coefficient indicated that for each increase of 0.001 percentage units in nitrate content of the forages, the fertility level declined one percentage unit. While not significant, this trend is in general agreement with a previous report by Banerjee et al. at this station.

Of the various forages sampled, grass hays appeared to be most likely to contain high levels of nitrates and pastures were least likely.

EFFECT OF PRONASE ON SUBSEQUENT DEVELOPMENT OF MOUSE EMBRYOS

C. R. Mochow and D. Olds

The zona pellucidas of two- and four-cell mouse ova were removed with a 0.5% pronase (W/V) in Earle's solution. Ova were divided into three groups: (1) control, zona pellucida intact; (2) P_1 , exposure to pronase long enough to remove the zona (3-6 minutes); and (3) P_2 , exposure to pronase an additional 5 minutes after removal of the zona. The ova were cultured at 37C under 5% CO_2 , in a modified Earle's solution containing lactate, pyruvate, albumin, antibiotics, and Fungizone. Ova were cultured 48 hr to estimate the percentage growing to blastocyst.

Among 59 control ova, 58% developed to blastocyst, whereas among 57 P_1 ova, 59% developed, and among 71 P_2 ova 42% developed. Statistical analysis indicated that significantly fewer P_2 ova developed to blastocysts ($P < 0.05$). There was no difference between controls and P_1 ova. Only in rare cases did the 5-minute exposure to pronase result in separation of the cells into isolated blastomeres, although 2-cell rat ova are said to separate readily with this treatment.

In the case of 109 blastomeres obtained from 2- to 4-cell ova by treatment with pronase for up to 12 minutes after zona removal, 1.8% developed to the 2-cell stage, 1.8% to the 3-cell stage, 3.7% to 4-cells, 15.5% to morullae and 36% formed random, monolayer configurations of 8-20 cells after 48 hr in culture.

FEED INTAKE AND EMBRYO SURVIVAL IN GILTS

R. H. Dutt and C. H. Chaney

Feed intake during the first part of gestation has been shown to affect embryo survival in gilts. Numerous reports indicate that high levels of energy following breeding increase embryonic death rate. It is a common practice to flush gilts, starting 10 days to 2 weeks prior to breeding and to maintain them on the high level of feed until all gilts of a group are bred. Some gilts may thus be on a high level of feed intake for 10 to 20 days after breeding.

The study reported herein was designed to determine (1) effects of level of feed intake on embryo survival to 40 days post-breeding, and (2) whether there is a detrimental carry-over effect of flushing on embryo survival. Sixty-four Yorkshire gilts were randomly assigned after the second estrous period to eight experimental

Table 1. — Average Ovulation Rate, Litter Size and Percent Embryo Survival to 40 Days Postbreeding

Item	Full Fed from Seventh Day of the Cycle Prior to Breeding to:						Full Fed From Day 1 to Day 16 of Cycle Prior to Breeding	
	Group I Breeding, slaughtered 3 days later	Group II 40 days post- breeding	Group III Breeding, then reduced to 5.5 lb/day	Group IV Breeding, then reduced to 2.75 lb/day	Group V 10 days post breeding, then reduced to 5.5 lb/day	Group VI 10 days post breeding, then reduced to 2.75 lb/day	Group VII Then reduced to 5.5 lb/day	Group VIII Then reduced to 2.75 lb/day
Average ovulation rate	15.2	15.5	16.9	15.5	14.6	15.2	15.4	14.9
Average live embryos per gilt at 40 days	98.2 ^a	13.2 ^b	11.8	12.8	10.5	12.0 ^b	11.9	10.9
Percent embryo survival	---	67.3 ^b	67.4	83.6	71.8	59.0 ^b	76.8	73.1

^a/Percent of ova cleaved.

^b/Two gilts in the group did not conceive. Average litter size is based on pregnant gilts, embryo survival is based on corpora lutea in all gilts.

groups (Table 1). Gilts in Groups I through VI were flushed (full fed about 9 lb per gilt daily) from the seventh day of the estrous cycle prior to breeding. For fertility data, gilts in Group I were slaughtered the third day after breeding, and those in Group II were full fed to 40 days postbreeding. In Groups III through VI feed intake per gilt was reduced to 5.5 or 2.75 lb daily at time of breeding or at 10 days postbreeding. Gilts in Groups VII and VIII were full fed from the second estrous period until the sixteenth day of the cycle prior to breeding; thereafter, the gilts in these two groups received either 5.5 or 2.75 lb of feed daily. All gilts in Group II through VIII were slaughtered 40 days postbreeding.

A summary of the breeding performance of the gilts is given in Table 1. Gilts flushed for the first 16 days of the cycle had nearly the same ovulation rate (15.2) as those flushed from day 7 of the cycle until the next estrous period (15.4). In gilts full fed to 40 days postbreeding 63.7% of corpora lutea (CL) were represented by live embryos. In gilts full fed to 10 days postbreeding 65.4% of the CL were represented by live embryos, and in gilts in which feed intake was restricted at time of breeding, 75.5% of the CL were represented by live embryos. There was no difference in embryo survival to 40 days postbreeding when daily feed intake after flushing was reduced to 5.5 or to 2.75 lb per gilt (72.0 vs. 71.9%, respectively). Embryo survival was 74.9% when feed intake was reduced on the sixteenth day of the cycle. This is nearly the same survival rate (75.5%) found when intake was restricted at time of breeding. This comparison suggests that there is no significant detrimental carry-over effect from flushing on early embryo survival.

Embryo survival was higher ($P < .01$) when feed intake was reduced just before or at time of breeding (Groups III, IV, VII and VIII -- 75.1%) than when feed intake was reduced 10 days postbreeding or when gilts were maintained on full feed (Groups II, V and VI -- 64.7%).

SELECTIVE BREEDING FOR EARLIER LAMBING IN SOUTHDOWN SHEEP

R. H. Dutt and P. G. Woolfolk

It is recognized that many breeds of sheep exhibit a restricted breeding season, which can be detrimental to their productivity. This may be especially true under farm flock conditions where, with the trend toward more intensive lamb production, it appears desirable for ewes to have the potential to breed during all months of the year. Studies with limited data show fairly high heritability estimates for date of lambing in the Southdown and Hampshire breeds, indicating that progress could be made through selection for date of lambing. Thus, the possibility of altering the breeding pattern of these breeds through selection seems to be worthy of investigation.

Selection for earlier date of lambing has been practiced in a flock of purebred Southdown sheep closed to outside breeding since 1957. Ewes failing to lamb and late-lambing ewes have been culled each year, and since 1961 about one-third of the breeding flock have been replaced by the earliest-born yearling ewes. Three breeding groups of 21 ewes each are maintained each year, and only yearling rams have been used as sires. Sire selection has been made solely on date of birth; i.e., the earliest-born ram lamb by each sire has been used as a sire in the flock as a yearling. Sires are used for only one year, and rams have been turned in with the breeding groups on August 1 for a period of 120 days. No apparent advantage has been gained by placing

the rams with the ewes prior to August 1, since the number of ewes cycling prior to this date has been almost nil. Inbreeding has been kept to a minimum by avoiding parent-offspring and half-sib matings. To date there has been no indication of the appearance of recognized undesirable recessive traits.

An 8-year summary of the average date of first estrus, average lambing date, lambing rate, and percentage of ewes lambing is shown in Table 1. There has been a trend toward earlier date of lambing (on the average about 3.6 days earlier each year) and an increase in number of multiple births. The shift in average lambing date has been due principally to a decrease in the percentage of late-lambing ewes. Average date of first estrus, as determined by rams fitted with a marking harness, has also tended to be earlier (on the average nearly 3 days earlier each year). The unadjusted repeatability estimate for date of lambing in the flock is 0.33. This estimate is highly significant and is similar to earlier estimates reported for repeatability of date of lambing in Hampshire and Southdown ewes.

These data indicate that some progress has been made through selection for earlier lambing. Since initiation of the project, selection has been practiced for approximately four generations on the sire side and for approximately two generations among dams. There was no intentional selection for multiple births. It is possible that the increase in lambing rate may have been an indirect response from the rigid culling of barren ewes each year. In addition to the increased lambing rate, there was about a 2% increase in the percentage of ewes lambing each year as a result of culling the barren ewes.

Table 1. — Eight-year Summary of Breeding Performance in a Flock of Southdown Sheep Where Selection for Earlier Lambing Has Been Practiced

Breeding Season	Average Date of First Estrus ^{a/}	Average Date of Lambing	Lambing Rate	Percent of Ewes Lambing
1959	Sept. 30	Mar. 15	1.48	80.4
1960	Sept. 20	Mar. 25	1.43	85.7
1961	Sept. 27	Mar. 6	1.50	93.3
1962	Sept. 16	Mar. 11	1.38	96.8
1963	Sept. 7	Mar. 7	1.48	90.0
1964	Sept. 28	Mar. 1	1.73	95.2
1965	Sept. 12	Feb. 25	1.67	96.7
1966	Sept. 1	Feb. 23	1.60	96.8

^{a/} Date of first estrus was recorded as date when ewe was first marked by a ram fitted with a marking harness.

EFFECTS OF UNILATERAL CASTRATION ON BODY WEIGHT AND ACCESSORY GLAND DEVELOPMENT IN RAM LAMBS

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

Androgens produced by the interstitial cells of the testes have a direct effect on accessory gland development in the male. Androgens also appear to exert some influence on body growth, since intact males usually will gain faster than castrates. In rats a very high correlation has been found between size of testes and the androgen-dependent organs, such as the accessory sex glands. Removal of one testis is a method of altering the size of the testicular mass and will provide data for comparing the effect on accessory gland development and on body growth.

The purpose of this experiment was to study the effects of unilateral castration in ram lambs. The experiment was designed to study ipsi- and contralateral effects of unilateral castration. Forty ram lambs (Southdown rams x western cross ewes), ranging in age from 12 to 48 days, were allotted on the basis of age into 4 groups of 10 each. Ram lambs in one group were bilaterally castrated, those in the second and third groups were unilaterally castrated on the right or the left side, respectively, and those in the fourth group served as controls. All were slaughtered after they reached approximately 80 lb in weight at about 6 months of age.

The data are summarized in Table 1. Compensatory growth occurred in the remaining testis when one was removed, since the single testis in the unilateral castrate weighed on the average 71% as much as the combined weight of both testes in intact rams. There were no significant differences between the weights of the right and left testis, the seminal vesicles or the bulbourethral glands within any of the groups. The single testis of the right and left unilateral castrates was significantly ($P < .05$) heavier than the right or left testis of the controls (right, 145.2 vs. 195.6 gm; left, 140.2 vs. 211.1 gm). Average weight of the testis in the two unilateral castrate groups did not differ significantly.

Unilateral castration had no significant effect on growth rate, since average age at slaughter was nearly the same for the unilateral castrates and for intact rams. Bilateral castration depressed growth rate, and as a result, the wethers required a significantly ($P < .05$) longer period to reach slaughter weight. Seminal vesicle weights in the unilateral castrates also were not significantly different from those in the controls. In the bilateral castrates these glands weighed only 7.6% as much as did those in the intact males. Unilateral castration significantly reduced average weight of the bulbourethral glands (0.83, 0.57 and 0.70 gm in the control, right unilateral castrate and left unilateral castrate groups, respectively). In the bilateral castrates the bulbourethral glands weighed only 6.6% as much as did those in the controls.

These results suggest that in the young ram the bulbourethral glands are more sensitive than the seminal vesicles to circulating levels of endrogens. There was no evidence of a significant ipsilateral or contralateral effect of unilateral castration on development of the accessory sex glands.

Table 1. — Weight of the Testes and Accessory Sex Glands after Unilateral Castration of Ram Lambs

Treatment Group	Age at Slaughter, Days	Weight at Slaughter, lb	Weight, gm							
			Testes		Seminal Vesicles			Bulbourethral Glands		
			Right	Left	Right	Left	Both	Right	Left	Both
Control	172	83	145.2	140.7	3.70	3.71	7.41	0.82	0.83	1.65
Bilateral castrate	192*	82	---	---	0.29	0.27	0.56**	0.06	0.05	0.11**
Right testis removed	173	82	---	211.1	3.70	3.44	7.14	0.60	0.57	1.17 ^a
Left testis removed	170	85	195.6	---	3.69	3.74	7.43	0.71	0.70	1.41 ^b

a/ Significantly ($P < .01$) different from controls.

b/ Significantly ($P < .05$) different from controls.

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

**Significantly ($P < .01$) different from all other groups.

COMPARISON OF MAP AND PROGESTOGEN IMPREGNATED VAGINAL SPONGES FOR SYNCHRONIZING ESTRUS IN EWES

W. P. Deweese, H. A. Glimp and R. H. Dutt

Several experiments have shown that orally administered synthetic progestogens such as 6-methyl-17-acetoxypregesterone (MAP) are very effective in inhibiting estrus in the cycling ewe. More recently data have been reported showing that vaginal sponges will give the same effect without the disadvantages associated with a 14-day feeding period. The sponges, when inserted in the vagina of the ewe, released sufficient amounts of the hormone to prevent the occurrence of estrus. The objective of this experiment was to determine the effect of sponges impregnated with medoxyprogesterone acetate (MAP) and the oral administration of MAP on the breeding performance of ewes early in the season.

Ninety-two Northwestern crossbred ewes were randomly allotted within age groups to four treatments. One group was treated with sponges impregnated with 40 mg of MAP, and the second group received sponges impregnated with 60 mg of MAP. The third group was fed MAP for 14 days, and the fourth group served as a control. The MAP-treated group received 60 mg of MAP/head daily, mixed in one-half pound of finely ground corn. The other three groups were also fed one-half pound of corn per day so as not to bias the experiment. Treatments were started on July 22.

Fourteen days after treatment began in the three treated groups, the MAP feeding was discontinued and the sponges were removed from their respective groups. All four groups were then turned to pasture with 10 fertile Hampshire rams equipped with marking harnesses to aid in detecting heat. Date of conception was determined as the marking date that was confirmed by lambing after a normal gestation length.

Results of this experiment are summarized in Table 1. There were essentially no differences in the number of ewes showing estrus in the first 5 days after treatment in the 3 treated groups. Very few of the control ewes exhibited estrus during the first 2 weeks after the rams were turned with the ewes, while all of the treated ewes had exhibited estrus during this period.

Table 1. — Lambing Performance

Item	Treatment Group			
	MAP	40 mg	60 mg	Control
Ewes lambing, %	86.9	100.0	91.3	95.6
Av. No. days from end of treatment to conception	14.2	10.8	12.7	16.9
Lambing rate	1.75	1.83	1.71	1.82
Lambing percent ^a /	152	183	157	174

^a/ Number of lambs born per 100 ewes bred.

The groups treated with 40 mg sponges gave the best performance, as shown by the data in Table 1. One hundred percent of this group lambed with a lambing rate of 1.83. Both of the groups treated with sponges had a higher percentage of the ewes lambing and higher lambing rates than did the MAP group.

In conclusion, vaginal sponges were as effective as oral administration of MAP for synchronizing estrus in ewes. Also, ewes treated with the sponges conceived in fewer days after treatment and had more lambs per ewe.

PITUITARY GONADOTROPIN LEVELS AT DIFFERENT STAGES OF THE ESTROUS CYCLE OF THE EWE

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

An attempt has been made to correlate changes in pituitary FSH and LH levels to changes in the amino acid profile of the anterior pituitary gland of the ewe. Results of a previous trial reported in 1967 showed that, while the FSH and LH content of pituitaries from ewes exposed to different photoperiods did not differ significantly on the third day of the cycle, pituitaries from the controlled photoperiod groups (continuous light or 22 hours of total darkness per day) had a significantly ($P < .01$) lower threonine content than did pituitaries from the controls. These results were interpreted to mean that the amino acid composition of the pituitary gland does, in fact, vary significantly, and that the observed change was related to different photoperiod treatments. Further research was initiated to obtain pituitaries from ewes at different stages of the estrous cycle. Glands collected at different stages of the cycle should show differences in gonadotropin levels, and thus may be suitable for determining whether pituitary FSH and LH levels are associated with amino acid changes in the pituitary gland.

Twenty-one cycling, mature, crossbred ewes were stratified by age and randomly divided into three equal groups. Ewes in one group were slaughtered at 35 hours after the beginning of estrus, those in the second group on day 6 of the estrous cycle and those in group 3 on day 15 of the estrous cycle. Within 15 minutes after death, the anterior pituitary glands were removed and immediately frozen on dry ice (-79°C). The glands were trimmed, weighed and homogenized in 0.85% saline with a glass-on-glass homogenizer and stored at -20°C until assayed for LH and FSH. LH concentration in the individual glands was determined by the ovarian ascorbic acid depletion method of Parlow, and FSH levels were determined by the ovarian weight augmentation method of Steelman and Pohley. The results of these assays are reported in Table 1.

Table 1. — Pituitary Levels of LH and FSH at Different Stages of the Estrous Cycle of the Ewe

Stage of Cycle	LH ^a	FSH ^a
35 hours after onset of estrus	1233.9 $\pm$ 156.9 ^b	613 $\pm$ 82.7 ^d
Day 6 of estrous cycle	2183.8 $\pm$ 351.6 ^c	731 $\pm$ 91.8
Day 15 of estrous cycle	3867.6 $\pm$ 407.2	945 $\pm$ 100.6

^a/ Mean and standard error of total mcg of NIH-LH-S12 and FSH-S4 per gland.

^b/ Mean significantly ($P < .05$) lower than day-6 stage.

^c/ Mean significantly ($P < .01$) lower than day-15 stage.

^d/ Mean significantly ($P < .05$) lower than day-15 stage.

Ovulation occurs approximately 35 hours after the onset of heat in the ewe and, therefore, the pituitary gland should contain a lowered content of LH and FSH at this time. Glands collected 35 hours after the onset of estrous contained a significantly ($P < .05$) lower LH and FSH content than did glands collected on day 15 of the estrous cycle. Since the average estrous cycle in the ewe is approximately 17 days in duration, glands collected on day 15 or just before onset of estrus would be expected to contain high levels of LH and FSH. Glands collected on day 6 of the cycle should contain levels of LH and FSH that would fall between the 35-hour and 15-day groups, as was shown by the data.

The pituitary glands in the three experimental groups are also being analyzed for free and bound amino acid content. The significant changes in FSH and LH levels among the three groups of glands will be correlated with changes in amino acid content of the glands.

OXYGEN CONSUMPTION BY SPERM CELLS FROM HEAT-STRESSED RAMS

R. S. Sand, P. R. Dame and R. H. Dutt

It is widely recognized that high environmental temperatures have a detrimental effect on spermatogenesis in rams. This study was conducted to determine the effects of heat stress on the metabolism of ram sperm as measured by oxygen consumption.

Five mature, unshorn Southdown rams ranging in age from 2 to 5 years were stressed at 90° and 60 to 70% relative humidity for a period of 7 days. The average rectal body temperatures before, during, and after stress were 102.0, 104.5 and 102.3°F respectively. Body temperature of the rams were significantly higher during the stress period.

Samples of semen were collected at weekly intervals for a period of 19 weeks with an artificial vagina. Volume of the first ejaculate was determined and the percentage of motile cells was estimated from examination of samples of each ejaculate under a high-power microscope. Sperm cell concentration and the percentage of morphological abnormal cells were counted, using a hemocytometer. Oxygen consumption was measured with a Warburg constant volume respirometer.

Results presented in Table 1 are for 1, 4 and 13 weeks post treatment. Sperm collected during week 1 represent cells which were stored in the epididymis during the treatment period. During the fourth week post-treatment sperm cell concentration and motility were found to be lowest, and in ejaculates collected during week 13 post-treatment sperm cell concentration and motility had risen to levels considered to be normal for fertile rams during the breeding season.

This study was initiated the first of June, and the low average concentration (394 million cells/ml) shown for week 1 probably reflects the usual summer decline noted in ram semen. The high proportion of abnormal cells (56.8%) is also characteristic of Southdown rams at this time of year.

Average oxygen consumption was 3.7 microliters per 100 million cells during week 1, compared with 3.9 microliters for week 13. Even though there were large differences in the percentage of abnormal cells, in sperm cell concentration, and in

the percentage of motile cells between samples collected during these two periods, oxygen consumption was nearly the same. Other workers have shown that a decrease in concentration of sperm cells in the ejaculate results in an increase in the rate of oxygen consumption.

Table 1. — Effect of Heat Stress on Semen Characteristics

Weeks after Treatment	Volume 1st Ejaculate (ml)	Motile Cells, %	Sperm Cell Concentration, 10 ⁶ /ml	Abnormal Cells, %	Oxygen Consumption ^{a/}	
					Per ml of Semen	Per 10 ⁸ Sperm Cells
1	0.36 ^{b/}	10	394	56.8	7.1	3.7
4	0.10	0	38	56.6	44.8	171.2
13	0.56	50	2,924	7.1	130.8	3.9

^{a/} Microliters of oxygen consumed during 1 hour of incubation.

^{b/} All values are means for observation on five rams.

The effect of sperm cell concentration in the ejaculate is more apparent when data are compared for weeks 4 and 13 when sperm cell concentrations were 3.8 million and 2,924 million cells per ml, respectively. At the lower concentration, oxygen consumption was 171.2 microliters compared with 3.9 microliters per 100 million cells at the higher concentration.

It has been demonstrated that oxygen consumption is inversely related to concentration and that oxygen consumption is not dependent on motility, since sperm cells that are non-motile and presumably dead consume oxygen. When motility and sperm cell concentration were lowest during the fourth week, oxygen consumption was highest, both on the basis of number of sperm cells and per milliliter of whole semen. In week 1 the rate of oxygen consumption per 100 million cells was similar to that for week 13; however, on the basis of oxygen consumption per milliliter of semen, the values were 7.1 and 130.8 microliters, respectively, for the two periods.

The lower volumes of first ejaculates (0.10 vs 0.56 ml for weeks 4 and 13, respectively) may also result in a change in the chemical composition of the ejaculate which could, in turn, affect oxygen consumption.

From this data it appears that oxygen consumption is not a very satisfactory method of comparing the metabolic rates of sperm in samples of semen varying widely in sperm cell concentration.

CAUSES OF INFERTILITY IN BEEF COWS

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

According to USDA estimates the calf crop for all beef cattle in the United States in 1967 was 79.5%. Improvement in the percentage of cows calving would result in more efficient production of beef. Therefore, studies designed to determine some of the reasons for failure of reproduction among beef cattle are needed.

This study was initiated in an attempt to characterize some of the possible causes of infertility or subfertility among beef cows. The experimental animals used in this study were 35 purebred cows (Hereford, Shorthorn and Angus) that had been culled from the West Kentucky Substation (Princeton) and Coldstream Farm beef herds because of infertility. These cows had failed to conceive during the normal breeding season (May and June).

The cows were checked twice daily for a 60-day period with an aproned bull to detect estrus and establish whether they were cycling normally. At the onset of the second estrus period, each cow was bred naturally and slaughtered 3 days later. The reproductive tracts were recovered, and measurements of the uterus and ovaries were taken. Ova were recovered by flushing the oviducts and uterine horns. Conditions of the tract and ovaries were observed, and uterine sections plus the ovary on which ovulation had occurred were frozen for future study. Cows not showing estrus were slaughtered at the end of the 60-day period.

During the 60-day experimental period 57.1% of the cows exhibited normal cycles (18 to 23 days). Abnormal cycles (longer than 23 days) occurred in 17.1% of the cows, 11.4% had only one heat during the test period, and 14.3% did not exhibit estrus. Ova were considered to be fertilized if sperm were found in the zona pellucida or if cleavage had occurred. On this basis, 48.6% (17 of 35) of the cows had fertilized eggs. If those cows with normally cleaving ova are considered, then only 40.0% of the cows had fertilized ova. Of all the ova recovered, 56% were cleaved and 14.3% were considered to be abnormal because of broken zonae or fragmenting cells. Ova were not recovered from 20% of the cows that had ovulated. Abnormal reproductive tracts were found in 28.6% of the cows.

It should be pointed out that these data are from a selected group of cows that failed to conceive. The major causes of infertility appear to be (1) failure of cows to show estrus or normal estrous cycles, (2) failure of fertilization, and (3) abnormal reproductive tracts.

ANIMAL NUTRITION SECTION

THE REHABILITATION OF CAGE LAYING HENS

J. J. Begin

A physiological characteristic of laying hens is a decrease in productivity and egg quality, especially egg shell texture, as the length of laying time progresses. In recent years there has been considerable interest in force molting laying hens at the termination of a 12- to 14-month period of lay. It is believed that this technique may be a satisfactory method of extending the productive life of a hen and thus reducing the depreciation cost that must be charged against each bird.

The purpose of this experiment was to study the feasibility of force molting and rehabilitating caged hens. Since caged birds have been maintained in wire-floored pens with limited movement for long periods of time, it was of particular interest to determine whether or not it would be beneficial to rest these birds on range.

Experimental Procedure

In this experiment 360 S. C. White Leghorn hens of approximately 72 weeks of age were used. These hens at the termination of their first laying year were weighed, the lights were turned off, and both feed and water were removed for 24 hours. At the end of the 24-hour period the water was turned on each day at noon and off again at 5:00 p. m., and the birds were fed only a mixture of ground yellow corn and ground whole oats. This regime was continued for 8 days, at which time egg production had ceased. When egg production had ceased, 180 hens from alternate cages were selected and removed to a natural grass range and housed in 10 x 12 range shelters. The remaining 180 hens were maintained in individual cages. A 15 percent protein growing diet was fed to both groups during the rehabilitation period. After a rest period of 6 weeks, all of the birds were weighed and regrouped into single cage units. The birds from each group were randomly placed in alternate blocks of 10 hens each throughout the house. All birds were fed a standard 16 percent protein laying diet. Egg production, feed consumption, and mortality records were kept on a 28-day basis. During each experimental period, all eggs laid on two consecutive days were marked, weighed and broken out for interior quality and shell thickness measurements. The experiment was conducted for eight 28-day periods after the hens had returned to production.

Results

Table 1 shows the average rate of production and the amount of feed consumed per dozen eggs produced for each of the eight experimental periods and for the last 28-day period before force molting. The results indicate that birds rehabilitated on range lay more eggs and are more efficient than hens rested in cages. It also was observed that the rate of decline in production and efficiency during the post-molting period was less for the range birds than for the house birds.

The effects of force molting on range and in cages on egg weight and egg quality are shown in Table 2. There were no significant differences between the two methods of rehabilitation for any of the egg characteristics measured. It was noted that hens

after force molting, regardless of subsequent treatment, laid larger eggs with a higher interior quality and with better shell texture than they did during the last 28-day period of their first laying year.

Table 1.— Hen Day Production, Feed Utilization and Egg Weights of Range and House Force Molted Hens by Periods. Trial 1

28 Day Period	Hen Day Production		Feed Per Dozen Eggs	
	Range	House	Range	House
	%	%	lb.	lb.
Preliminary*	68.6	68.6	4.29	4.29
1	69.4	63.7	5.24	5.35
2	63.9	60.2	5.52	5.70
3	61.9	49.7	6.10	7.24
4	51.5	45.7	7.05	8.31
5	60.3	51.5	6.26	7.57
6	62.1	60.5	5.67	6.07
7	62.3	57.3	5.36	5.96
8	65.9	58.2	4.98	5.93
Average	61.95**	55.85	5.77**	6.52

*Last 28 day period before force molting

**Significant at the 0.01% level

Table 2.— Haugh Units and Shell Thickness of Range and House Force Molted Hens by Period. Trial 1

28 Day Period	Avg. Egg Wt.		Haugh Units		Shell Thickness	
	Range	House	Range	House	Range	House
	gm	gm			.001 in.	.001 in.
Preliminary*	60.0	60.0	59.3	59.3	.014	.014
1	62.13	63.07	68.9	70.7	.016	.015
2	63.72	61.70	69.2	67.0	.015	.015
3	62.72	64.45	65.4	65.7	.015	.015
4	63.37	63.58	65.1	65.3	.015	.015
5	63.28	64.50	62.9	66.0	.015	.015
6	63.30	64.18	65.4	67.6	.015	.015
7	63.00	63.13	66.8	65.5	.014	.015
8	61.05	63.32	65.2	67.9	.014	.014
Average	62.82	63.49	66.1	67.0	.015	.015

*Last 28 day period before force molting

Summary

The results of this experiment indicate that force molting can be used to extend the productive life of cage laying hens. The data presented also show that if caged

birds are removed from their cages and rested on range they will return to production and lay at an acceptable rate of lay, and that the eggs will be somewhat larger in size and have better interior quality and shell texture than they did prior to force molting.

EFFECTS OF REARING METHOD AND PROTEIN PHASE FEEDING ON THE REPRODUCTIVE PERFORMANCE OF CAGE LAYING HENS

J. J. Begin

Previous studies conducted at both the Robinson and Western Kentucky Sub-stations have indicated that pullets continue to gain weight and develop body tissues for a period of four or five months after the onset of egg production. To support both growth and egg production, a higher protein level is needed in the diet during the early part of the laying period than is required during the latter part of the reproductive cycle.

This experiment was conducted to investigate the effects of lowering the protein level of the diet after 5 months of production. Included in this study was a comparison of the subsequent productive performance of range- and house-reared pullets.

Experimental Procedures

Six hundred S. C. White Leghorn pullets, 11 weeks of age, were weighed, vaccinated for fowl pox and Newcastle disease, and distributed by weight into 2 groups of 300 birds each. One group was reared on a natural grass range while the other group was housed in an open sided house, allowing 2 square feet of floor space per bird. Both groups were fed a standard 15 percent protein growing mash during the growing period.

At 18 weeks of age both groups were weighed and 480 pullets were selected on the basis of body weight and sexual maturity. The selected pullets were housed in individual hen cages, and the experimental diets were assigned in a random manner so that each dietary regime was fed to 6 replicated groups of 10 hens each.

Results and Discussion

The experimental design and production data are shown in Table 2. There were significant differences in rate of lay between the groups fed the 12 and 16 percent protein diets for the entire period and between the house and range reared pullets fed the low protein diet for their entire production cycle. No significant differences were observed between the other dietary regimes in regard to their influence on egg numbers.

Rearing method had no significant effect on egg size. The pullets receiving the 16 percent protein diet continuously laid eggs that were significantly heavier than any of the other groups except the house-reared pullets on the same feeding program. Of particular interest are the egg size data of the four groups which were started on the 16 percent protein diet. A significant reduction in egg size was obtained when the groups receiving the 16 percent diet were switched to the 12 percent protein diet the last 7 months of production. Since eggs are sold by the dozen and not by weight, the larger egg size at the end of the laying period often results in an egg handling problem; thus, phase feeding would eliminate this characteristic.

A more critical evaluation of the effects of protein phase feeding is obtained when the production efficiency index is calculated. This index takes into account egg numbers, egg weight, and feed consumed. The data reveal that the best results are obtained when a 16 percent diet is fed for the entire laying cycle, as these pullets were significantly more efficient than the pullets on any of the other feeding regimes. The pullets reared on range and fed the 12 percent protein diet for the first 5 months and then fed the 16 percent protein diet, or the house- and range-reared birds fed the low protein diet during the last phase only, were significantly more efficient than those fed the low protein diet throughout or those reared in the house and fed the low-high protein regime. It is obvious from the production efficiency data that the protein status of range-reared birds at housing time is superior to that of pullets reared in confinement. There were significant differences in production efficiency between range- and house-reared pullets in all groups that were started on the 12 percent protein diet, but no differences were observed between rearing methods when the birds were initially fed a 16 percent protein diet. This difference in response to the low protein diet during the first phase of production indicates that range-reared birds are not as susceptible to a protein deficiency as are house-reared pullets.

Table 1. — Composition of Experimental Diets

Ingredients	12% Protein	16% Protein
	Diet %	Diet %
Ground yellow corn	71.50	61.50
Wheat Stan. Middlings	10.00	10.00
Dehulled Soybean Meal	3.00	13.00
Meat and Bone Scraps (50%)	5.00	5.00
Alfalfa Meal (17%)	2.50	2.50
Dicalcium Phosphate	2.50	2.50
Ground Limestone	5.00	5.00
Salt	0.25	0.25
Vitamin-Mineral Premix ^{1/}	0.25	0.25
	100.00	100.00

^{1/} Supplied per kilogram of diet: 5500 I.U. vitamin A, 1650 I.C.U. vitamin D₃, 11 I.U. vitamin E, 4.4 mg. riboflavin, 22 mg. niacin, 6.1 mg. d-pantothenic acid, 220 mg. choline chloride, 6.6 mcg. vitamin B₁₂, 11 mg. menadione sodium bisulfite, 4.4 mg. bacitracin MD, 124.7 mg. butylated hydroxy toluene, 59.9 mg. manganese, 27.5 mg. zinc, 1.2 mg. iodine, 20 mg. iron, 2 mg. copper and 0.2 mg. cobalt.

Calculated Analysis

Crude Protein (%)	12.00	16.00
M. E. / lb. (Kcal.)	1308	1265

Table 2. — Effect of Rearing Method and Phase Feeding on Reproductive Performance of Cage Layers

Rearing Method	Protein Level		Hen Day Production	Ave. Egg Weight gm	Production ^{1/} Efficiency gm
	0-5 mo %	6-13 mo %			
House	12	12	59.7c ^{2/}	58.0bc	0.270e
Range	12	12	64.8b	57.6c	.286d
House	12	16	67.5ab	58.4bc	.288cd
Range	12	16	69.7ab	57.7c	.297b
House	16	16	71.1a	58.8ab	.314a
Range	16	16	71.7a	60.1a	.318a
House	16	12	67.8ab	57.8c	.298b
Range	16	12	68.6ab	57.8c	.294bc

^{1/} $\frac{\text{Eggs Produced per Hen Day} \times \text{Ave. Egg Weight (gm)}}{\text{Feed consumed per Hen Day (gm)}}$

^{2/} Values are averages of 6 replicate groups. Figures with differing superscripts are significantly different ($P < 0.01$).

EFFECT OF PANTOTHENIC ACID LEVEL ON THE UTILIZATION OF ENERGY AND NITROGEN BY THE CHICK

J. J. Begin and W. N. Isgrigg

The importance of pantothenic acid in intermediary metabolism indicates that this vitamin must play a vital role in metabolism, but there is little direct evidence of its influence on the utilization of energy or nitrogen by the chick.

The study reported here was undertaken to study the role of pantothenic acid on metabolizable energy values and the efficiency of energy and nitrogen utilization as determined by carcass analysis during short-term experiments.

Experimental Procedure

Two experiments were conducted, one of a 10-day duration using male New Hampshire X Silver Cornish chicks and the second conducted for 20 days with straight-run White Plymouth Rock chicks. In both experiments all birds were fed a practical starting diet for the first 16 days and then a depletion diet (Table 1) for the next 5 days. At the end of the 21-day preliminary period, the birds were fasted overnight and weighed. The birds were then randomly distributed into 13 groups in such a manner that each group contained 5 birds of nearly equal weight. To determine tissue gains, one group was selected at random, sacrificed, frozen, and stored until analyzed for dry matter, nitrogen, and gross energy.

The depletion diet (Table 1) supplemented with a graded level of pantothenic acid was fed to triplicated pens. Equalized feed intake was maintained by daily feeding all pens the amount of feed consumed by the pen eating the least feed the previous day.

Table 1. — Composition of Basal Diet

Ingredient	Per cent
Cerelose ^{1/}	52.55
C-1 Assay protein	29.00
Gelatin	1.00
Solka floc	5.00
Corn oil	2.00
Mineral supplement ^{2/}	5.00
Vitamin supplement ^{3/}	5.00
Chromic oxide	0.30
Methionine hydroxy analog (90%)	0.15
	100.00

^{1/} All pantothenic acid premix additions were made at the expense of cerelose.

^{2/} The vitamin mix supplied the following per kg. of diet: vitamin A, 6600 I.U., vitamin D3, 660 I.C.U., vitamin E, 35 I.U., vitamin K, 0.55 mg, vitamin B12, 10 mcg, riboflavin, 3 mg, choline chloride, 1350 mg, niacin, 27 mg, pyridoxine, 3 mg, biotin, 0.1 mg, folic acid, 2 mg, thiamine, 2 mg, and Butylated hydroxy toluene, 125 mg.

^{3/} The mineral mix supplied the following per kg. of diet: calcium, 1.0%, phosphorus, 0.5%, potassium, 0.15%, sodium, 0.2%, iodine, 4 mg, molybdenum, 2 mg, magnesium, 500 mg, iron, 20 mg, manganese, 60 mg, zinc, 60 mg, cobalt, 6 mg, boron, 0.5 mg and copper, 10 mg.

Chromic oxide was added to the diets as an index material, and at the termination of each experiment excreta samples were collected from each pen. The excreta samples, together with a sample of the diet, were analyzed for moisture, gross energy, chromic oxide, and nitrogen by the usual laboratory procedures. From these data the nitrogen-corrected metabolizable energy values for each diet were determined.

At the termination of each experiment the birds were starved for 16 hours and weighed. All birds from each pen were killed without loss of blood, autoclaved, homogenized in a large blender, and an aliquot dried by lyophilization. The dried carcass samples were analyzed for nitrogen and gross energy.

Results

Shown in Table 2 are the results of experiment 1. The data indicate that 6 mg of pantothenic acid per kg of diet is adequate for growth and that no improvement in gains in weight was obtained as the pantothenic acid level was increased. The data also reveal that the level of pantothenic acid fed had no influence on the ability of the chick to derive metabolizable energy from the diet or the ability of the chick to utilize

dietary nitrogen. It appears from the results of this experiment that caloric efficiency is a sensitive measure for determining the pantothenic acid adequacy of chick diets since both the 6 and 8 mg per kg levels of pantothenic acid were significantly less efficient in promoting use of dietary energy than were the 10 and 12 mg per kg levels.

The results of trial 2 are shown in Table 3. This trial was of a longer period of time and a wider range of pantothenic acid levels were fed. The data show that the diet containing 3 mg of pantothenic acid per kg was deficient as it depressed appetite, weight gains, and caloric efficiency significantly. It is noted that even though the diet supplemented with 3 mg per kg of pantothenic acid was obviously deficient, the chicks were still able to derive as much metabolizable energy from the diet as did the chicks on the higher pantothenic acid levels. Considering the three higher pantothenic acid levels, it is observed that on equalized feed intake there were no significant differences in weight gains or in nitrogen and caloric efficiency, indicating that the pantothenic acid requirement of older chicks is no more than 6 mg per kg of diet.

Summary

Two short-term experiments were conducted to investigate the effects of pantothenic acid level of the diet on the ability of the chick to utilize nitrogen and energy.

The results indicate that the level of pantothenic acid has no influence on the ability of chicks to derive metabolizable energy from the diet; however, the level does affect caloric efficiency, measured as the percent metabolizable energy retained as tissue energy. No effect of pantothenic acid on nitrogen utilization was observed.

Table 2. — Effect of Pantothenic Acid Level on Weight Gains, Nutrient Intake and Efficiency of Nitrogen and Energy Utilization, Trial 1

Panto- thenic acid	Av. weight gain	Av. feed intake	Av. nitrogen intake	Av. M. E. value	Av. M. E. intake	Nitrogen ^{2/} retained	Energy ^{3/} retained
mg/kg	gm	gm	gm	Kcal/gm	Kcal	%	%
6	105 ^{1/}	312	12.33	3.21	1003	29.46	10.45b ^{4/}
8	107	312	12.37	3.22	1006	29.89	10.27b
10	107	312	12.37	3.22	1006	34.90	18.39a
12	105	312	12.37	3.22	1006	31.90	17.45a

^{1/} All values are averages of triplicate groups

^{2/} (Gain in carcass nitrogen, gm./nitrogen consumed, gm.) X 100

^{3/} (Kcal. gained / Kcal. of metabolizable energy consumed) X 100

^{4/} Means not bearing the same superscript are significantly different (P < 0.05)

Table 3. — Effect of Pantothenic Acid Level on Weight Gains, Nutrient Intake and Efficiency of Nitrogen and Energy Utilization, Trial 2

Panto- thenic acid	Av. weight gain	Av. feed intake	Av. nitrogen intake	Av. M. E. value	Av. M. E. intake	Nitrogen ^{2/} retained	Energy ^{3/} retained
mg/kg	gm	gm	gm	Kcal/gm	Kcal	%	%
3	272* ^{1/}	670*	28.29*	3.18	2131*	30.80	23.72*
6	352	788	33.24	3.20	2521	31.32	27.59
12	323	788	33.24	3.19	2513	30.53	28.22
24	336	788	33.24	3.18	2505	31.07	29.92

* Significant at the 0.05% level

^{1/} All values are averages of triplicate groups

^{2/} (Gain in carcass nitrogen, gm. / nitrogen consumed, gm.) X 100

^{3/} (Kcal. gained/Kcal. of metabolizable energy consumed) X 100

EFFECTS OF PROTEIN LEVEL OF THE DIET ON THE REPRODUCTIVE PERFORMANCE OF JAPANESE QUAIL (*Corturnix corturnix japonica*)

J. J. Begin

The Japanese quail has many advantages as a research animal since it grows rapidly, matures at an early age, and is a prolific egg producer. This species is well adapted for use in pilot experiments for chickens and turkeys because of its close resemblance to these species and the minimal space and feed requirements. Although the Japanese quail has been advocated for many areas of avian research, only limited information is available concerning its nutritional requirements.

This experiment was conducted to study the sensitivity of Japanese quail breeder hens to the protein level of the diet and to obtain data pertaining to the protein requirements of the species for reproduction.

Experimental Procedure

The two diets fed in this experiment are shown in Table 1. The protein levels of 15.6 and 20.7 percent were obtained by adjusting the corn, soybean meal, and solka-floc levels of the diets in such a manner so that the diets were maintained isocaloric with protein level being the only variable.

Ninety-six females and 32 males from a breeding flock maintained by the Poultry Section were selected at 4 weeks of age on the basis of body weight and sexual maturity and randomly distributed into 8 wire-floored pens. Each of the experimental diets was fed to 4 replicate pens, each containing 12 females and 4 males. The experiment was conducted for 7 periods of 28 days each. Daily egg records were obtained and feed consumption and body weight data were kept by periods. All eggs laid for 7 consecutive days during each period were weighed and incubated to obtain fertility and hatching data. Hen day production, egg weights, hatchability, and

Table 1. — Experimental Diets

Ingredients	Diet 66-5	Diet 66-6
	%	%
Ground Yellow Corn	61.92	53.56
Dehulled Soybean Meal	12.86	24.26
Alfalfa Leaf Meal	3.00	3.00
Fish Meal (60% Protein)	3.00	3.00
Defluorinated Phosphate	4.00	4.00
Ground Limestone	6.50	6.50
Salt	0.25	0.25
Vitamin-Mineral Premix ^{1/}	0.50	0.50
Solka-Floc	6.88	3.84
Corn Oil	1.00	1.00
Choline Chloride (70%)	.09	.09
	100.00	100.00

^{1/} Supplied per kilogram of diet: 5500 I.U. Vitamin A, 1650 I.C.U. Vitamin D₃, 11 I. U. Vitamin E, 4.4 mg. riboflavin, 22 mg. niacin, 6.1 mg. d-pantothenic acid, 220 mg. choline chloride, 6.6 mcg. Vitamin B₁₂, 11 mg. menadione sodium bisulfite, 4.4 mg bacitracin MD, 124.7 mg. butylated hydroxy toluene, 59.9 mg. manganese 27.5 mg. zinc, 1.2 mg. iodine, 20 mg. iron, 2 mg. copper and 0.2 mg. cobalt.

Analysis		
Crude Protein	15.60	20.70
Metabolizable Energy	1224	1228
Calcium	3.94	3.97

efficiency of production data were calculated by periods. The production efficiency was measured as a production index which was calculated as follows:

$$\frac{\text{Eggs Produced per Hen Day} \times \text{Average egg Weight (gm)}}{\text{Feed Consumed per Hen Day (gm)}}$$

This index represents the grams of feed required to produce a gram of egg, taking into account any mortality that occurred during the experimental period.

Results

The effects of dietary protein on reproductive performance are shown in Table 2. The data show that the protein level of the diet has a pronounced effect on the reproductive performance of the Japanese quail. It is observed that egg production, egg weight, production efficiency and hatchability were significantly improved when the dietary protein level was increased from 15.6 to 20.7 percent.

Table 2. — Experimental

Period	Hen Day Production		Ave. Egg Weight		Production Index		Hatchability	
	Low Protein	High Protein	Low	High	Low Protein	High Protein	Low Protein	High Protein
	%	%	%	%	gm	gm	%	%
1	74.96	79.81	9.48	9.99	0.230	0.242	54.35	61.47
2	66.92	83.43	8.93	9.49	0.185	0.241	61.60	79.60
3	71.09	84.30	9.25	9.57	0.186	0.221	43.30	63.02
4	73.88	83.17	9.10	9.52	0.196	0.232	45.61	59.98
5	68.73	82.95	9.25	9.75	0.176	0.216	41.88	41.32
6	55.00	67.39	9.22	9.72	0.150	0.184	26.90	38.56
7	60.95	74.30	9.25	9.85	0.176	0.210	49.42	46.23
Av.	67.36	79.33**	9.21	9.70**	0.186	0.221**	46.44	55.74**

**Denotes significant differences ($P < 0.01$)

The effects of protein level on egg production, egg weight, and production efficiency were very similar to those observed with chickens, and the rate of lay of the quail fed the higher protein level was comparable to that normally observed with high-producing egg-laying strains of chickens. The results of this experiment indicate that the Japanese quail would be a suitable pilot animal for studies involving protein as well as other nutritional factors affecting reproduction.

The observation that protein level has an effect on hatchability of Japanese quail eggs is contrary to the results obtained with chickens or turkeys. Most reports indicate that in general the protein level of the diet does not influence the hatchability of turkey or chicken eggs because the hen will not lay an egg deficient in an amino acid. Further work is necessary in the area of protein nutrition and hatchability.

Summary

The results of this experiment show that the Japanese quail is extremely sensitive to changes in the protein level of its diet and that a satisfactory reproductive performance is obtained when a diet containing 20.7 percent protein is fed. The data also indicate that this species of aves is suitable for pilot studies involving the effects of nutrition on reproduction.

APPARENT PROTEIN DIGESTION ANTERIOR AND POSTERIOR TO EQUINE CECAL FISTULAS

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

Since protein is the primary constituent of muscle and a component of all animal cells, both the quantity and quality of dietary proteins are major considerations in the

nutrition of all animals. Protein quality for animals with simple stomachs is associated mainly with balance and availability of amino acids. The extensive conversion of dietary nitrogen to microbial protein during microbial fermentation in the multiple stomach of ruminants requires that the extent and efficiency of this conversion be considered in evaluating dietary protein needs. There is also extensive microbial involvement in the digestive processes of equine animals. However, this microbial activity takes place after digestion in the stomach and small intestine rather than preceding this digestion as it does in ruminants.

The factors which determine dietary protein quality in horses have not been well defined. The site of digestive and absorptive activity in the gastrointestinal tract and the degree of microbial involvement are likely to be major determining factors in this definition. This study was designed to provide estimates of apparent protein digestion for three common grains anterior and posterior to the cecum.

Procedure

Three crossbred ponies with cecal fistulas were used with three rations in replicated Latin-squares. Protein in the three rations was provided by corn, oats, or barley. Estimated contents of total digestible nutrients and crude fiber were equalized by adding appropriate amounts of starch and cellulose. The resulting rations averaged 7.1% crude protein and 7.3% crude fiber. Chromic oxide (0.5%) was added for use in estimating digestion coefficients by indicator procedures. The ponies were fed twice daily during 10-day preliminary and 6-day collection periods. Cecal contents and fecal samples were collected twice daily to provide samples at each 2-hour interval after morning and afternoon feedings.

Results and Discussion

Apparent digestion coefficients for protein from corn, oats and barley for the anterior and posterior segments and the entire gastrointestinal tract are presented in Table 1. The apparent digestion of ration protein before reaching the cecal fistula averaged 10.7. Digestion of protein posterior to the fistula averaged 39.7%. Although total apparent protein digestion coefficients for corn and barley protein were higher than for oat protein, the differences were not significant. All coefficients were lower than usually reported for horses. This was probably due to the low protein content which magnifies the influence of endogenous protein.

These results suggest that most of the protein digestion in horses probably occurs in the cecum and colon and can be assumed to be dependent on microbial activity. As a result, suitability for digestion by microorganisms may be a significant consideration in evaluating protein quality for horses. It also seems probable that amino acid balance of the feed will prove to be less important for horses than for animals such as swine and poultry. Additional experimental work to explore these possibilities is needed.

Table 1. — Apparent Protein Digestion in Different Sections of the Digestive Tract of Ponies

Protein Source	Corn	Oats	Barley
Daily consumption, gm.			
Total ration	1431	1431	1431
Crude protein	106	103	96
Apparent protein digestion, %			
Mouth to cecal fistula	3.2	12.8	16.0
Cecal fistula to feces	47.3	31.4	40.0
Mouth to feces	49.5	41.7	50.8

DIGESTION OF ENERGY SOURCES BY EQUINE INTESTINAL MICROORGANISMS

B. H. Crawford, Jr., Sandi Lieb, J. P. Baker
G. E. Mitchell, Jr., and C. O. Little

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, primarily acetic, propionic, and butyric. The influence of type of ration upon the relative importance of these different sources of energy in supplying the total needs of the equine has not been elucidated. The dietary influence upon the type of fermentative processes occurring in the large intestine is of particular significance in this problem.

Procedure

Three mature horses were used as sources of inoculum for *in vitro* studies of starch and cellulose digestion by microorganisms from the cecum and dorsal colon. Two series of trials were conducted. In the first series the horses were fed oats plus clover-timothy hay, and in the second they were fed the same ration but were allowed daily access to green pasture. The inoculum was collected from two permanently-installed fistulae in each of the horses and placed under CO₂ to maintain anaerobiosis. Triplicate samples were strained, centrifuged, buffered to pH 6.8, and incubated for 24-hour digestion of starch and with cellulose substrates.

Results and Discussion

Results of the trials are summarized in Table 1. It is apparent that access to green pasture exerted a marked effect upon the microbial population in both the cecum

and dorsal colon. The comparatively high amylolytic activity in the cecum when the horses were being fed the oats and hay ration suggests that substantial quantities of starch from the grain undergo fermentation in this segment of the digestive tract of the horse. Conversely, the higher cellulolytic activity in the dorsal colon under both feeding regimes probably reflects the greater dependence of the microbes in this segment upon the more fibrous portions of the ration.

Table 1. — Twenty-four Hour *in vitro* Digestion of Starch and Cellulose by Microorganisms from the Cecum and Dorsal Colon of the Horse

	Starch		Cellulose	
	Cecum	Dorsal Colon	Cecum	Dorsal Colon
Oats and hay ration	52.1%	25.3%	2.0%	5.1%
Oats and hay and pasture	21.0%	31.9%	3.6%	9.7%

VOLATILE FATTY ACIDS IN EQUINE CECAL FLUID

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

The cecum of the equine and the rumen of the ruminant species both serve as fermentation vats for large numbers of microorganisms. In both cases fermentation of carbohydrates results in the production of volatile fatty acids, primarily acetate, propionate, and butyrate. Since rumen fermentation precedes and cecal fermentation follows gastric and intestinal digestion, a similar microbial activity may be of considerably different nutritional significance to the equine and to the ruminant because of differences in feed or feed residues presented to the microorganisms and differences in subsequent metabolism of the products of fermentation.

Many investigators have demonstrated the marked influence of ration composition upon the ratio of volatile fatty acids produced in the rumen, with high roughage rations resulting in high ratios of acetate and high concentrate or grain rations favoring the production of propionate. Reports relating ration composition to volatile fatty acids produced by cecal fermentation in the equine have not been found.

Procedure

Three crossbred ponies with cecal fistulae were fed the pelleted experimental rations, as shown in Table 1, in a 3 X 3 latin square design replicated in time. The ponies were individually fed and maintained in tie-stalls but were removed and led one-fourth mile each day for exercise. Following 10-day preliminary periods, cecal contents, representing each 2-hour interval after equally spaced morning and afternoon

feedings, were collected, composited by period and analyzed in duplicate for acetate, propionate and butyrate.

Table 1. — Composition of Experimental Rations

Ingredient	%	%	%
Oats	59.8	--	--
Corn	--	--	--
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
Vitamine A ₁ /	+	+	+

₁/Vitamin A added at 3000 I. U./kg feed.

Results and Discussion

The average molar percentages of the volatile fatty acids in the cecal fluid taken from the three ponies while they were being fed the three experimental rations are shown in Table 2. Although there are some differences in the average values shown, the differences between rations are not statistically significant. It is worthy of note that the molar ratios of the volatile fatty acids were similar to those which have been reported for rumen fluid from cattle being fed high concentrate rations. This suggests that a substantial amount of starch from these rations reached the ceca of the ponies and was subjected to fermentation to volatile fatty acids.

Table 2. — Average Molar Percentages of Volatile Fatty Acids in Cecal Fluid

Ration	Acetate	Propionate	Butyrate
Oats	51.2	36.1	11.0
Corn	57.8	30.6	11.6
Barley	54.3	32.8	13.0

PERFORMANCE OF S. P. F. YORKSHIRE HERD AT WEST KENTUCKY SUBSTATION FROM 1963 TO 1967

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

A primary S. P. F. Yorkshire herd was started at the West Kentucky Substation at Princeton in 1962. The herd has maintained its S. P. F. rating and is also qualified as an accredited brucellosis-free herd.

From 1963 to 1967 a performance testing program was followed in which daily gain, feed conversion, and carcass measurements were obtained on a barrow and a gilt from most of the litters. Performance data in the fall of 1967 were determined from pigs on other experiments and carcass data were obtained only on barrows.

Selection of replacement gilts has been based on individual performance, backfat probe, and carcass cutout of littermates. New bloodlines have been introduced into the herd by the use of artificial insemination.

A summary of the reproductive performance of sows and their litters from birth to three weeks is presented in Table 1. Performance of pigs from approximately 40 pounds to market weight and carcass measurements are presented in Table 2.

Table 1. — Reproductive Performance of Sows and Litters of West Kentucky Substation S. P. F. Yorkshire Herd

	No. Litters	Pigs Farrowed	Av. Pig Birth Wt. (lb.)	No. Pigs at 21 Days	Total Litter Wt. at 21 Days	Av. Pig Wt. at 21 Days
1963 Fall	12	12.25	2.68	9.67	92.4	9.56
1964 Spring	14	12.50	2.67	8.43	99.1	10.97
1964 Fall	28	10.29	2.61	7.82	74.6	8.85
1965 Spring	31	11.00	2.75	9.03	105.4	11.66
1965 Fall	18	10.28	2.89	9.06	104.3	11.57
1966 Spring	26	10.69	2.81	9.62	119.7	12.45
1966 Fall	22	11.05	2.94	9.59	111.5	11.63
1967 Spring	16	11.06	2.92	9.88	128.1	12.97
1967 Fall	18	11.61	2.76	9.28	109.0	11.74
Average		11.19	2.78	9.15	104.9	11.27

Table 2. — Performance and Carcass Traits of Pigs from West Kentucky Substation S. P. F. Yorkshire Herd

Year	Season	No. Pigs Tested	Av. Initial Wt. (lb.)	Av. Final Wt. (lb.)	Av. Daily Gain (lb.)	Feed Per Cwt. Gain	Dressing Percent	Carcass Length (in.)	Carcass Backfat (in.)	Loin Eye Area (sq. in.)	Lean Cuts % of Carcass	Ham and Loin % of Carcass
1963	Fall	18	44.6	200.5	1.86	333	72.08	30.46	1.74	4.07	48.90	33.99
1964	Spring	18	53.8	200.3	1.68	323	72.06	30.36	1.67	3.98	50.97	35.69
1964	Fall	20	48.5	200.0	1.74	352	71.96	30.82	1.61	3.99	50.30	35.16
1965	Spring	18	52.0	201.3	1.72	345	71.05	30.52	1.59	3.74	51.52	36.10
1965	Fall	18	41.6	200.6	1.74	337	71.77	30.71	1.48	4.38	52.38	36.15
1966	Spring	28	51.2	201.4	1.72	322	72.14	30.33	1.48	4.01	52.73	36.83
1966	Fall	28	51.2	201.6	1.82	325	71.80	30.77	1.40	4.29	53.78	38.09
1967	Spring	26	46.2	200.3	1.61	309	70.29	30.42	1.38	4.35	53.65	37.43
1967	Fall ¹	96	42.0	211.6	1.76	323	73.56	30.22	1.43 ²	4.63	54.41 ³	38.05
Average			47.9	202.0	1.74	330	71.86	30.51	1.53	4.16	52.07	36.39

¹ Carcass data on barrows only, 51 head, av. slaughter wt. of 215.9 lb.² Adjusted to 200 lb. An adjustment for sex would give an estimate of 1.38 in.³ Estimated (1.43 x % ham and loin).

EFFECT OF PROTEIN SOURCES AND LEVELS AND ORAL IRON FOR THE SOW ON REPRODUCTIVE PERFORMANCE

D. Spruill, V. W. Hays, and G. L. Cromwell

Experiment 1

Thirty-six Yorkshire and Hampshire sows were used in a 2 x 3 factorial experiment to compare two levels of protein (16% and 12%) and three sources of protein (soybean meal, low gossypol cottonseed meal, and fish meal) in corn-base diets on reproductive performance of the sows and performance of their pigs from birth to 3 weeks of age.

All rations were supplemented with vitamins and minerals and were fed at a level of 4 lb per day for an average of 94 days prepartum and fed ad libitum for 21 days postpartum. Beet pulp was substituted for 2.5% corn in all diets fed during lactation. The 12% ration was formulated by adding cerelese and starch to the 16% formulation to reduce the protein level and also maintain a constant amino acid balance within a protein source.

Blood samples were taken from six randomly selected pigs at birth and from the same pigs at 21 days. One-half of these pigs were injected with 100 mg of iron dextrin at one day of age.

A summary of sow and pig performance is presented in Table 1. Sows fed the cottonseed meal diets had fewer pigs at birth and at 3 weeks than did sows fed the soybean meal or fish meal diets. Hemoglobin and hematocrit levels at birth were highest for pigs from sows on the soybean meal diet. The lowest hematocrit and hemoglobin levels at birth and at 3 weeks were in pigs from sows fed the fish meal diet.

Table 1. — Reproductive Performance of Sows and Performance of Pigs as Affected by Protein Source and Levels Fed the Sow and Injectable Iron to the Pig (Experiment 1)

	Protein Source			Protein Level		Injected Iron	
	SBM	CSM	FM	12%	16%	100 mg	0
Birth							
Total pigs	11.67	8.10	11.22	10.64	10.16		
Live pigs	11.00	7.25	10.44	9.85	9.41		
Av wt, lb	3.06	3.46	3.28	3.37	3.13		
Hematocrit, %	37.18	35.43	35.04	36.07	35.70		
Hemoglobin, gm/100 ml	11.40	10.70	10.14	11.22	10.20		
3 Weeks							
No. pigs	9.44	5.13	8.00	7.78	7.42		
Av wt, lb	11.39	10.78	12.11	11.98	10.83	11.24	11.49
Hematocrit, %	31.58	29.17	26.89	28.85	29.64	31.84	26.59
Hemoglobin, gm/100 ml	7.98	8.21	7.00	7.54	7.91	8.79	6.67

The reproductive performance was slightly in favor of sows fed the lower protein level. Hemoglobin and hematocrit levels at 3 weeks were higher in pigs injected with iron dextrin than in those not injected.

Experiment 2

Thirty-six sows and gilts were used in a 2 x 3 factorial experiment to determine the effect of oral iron (no added iron vs. 700 ppm added iron from ferrous sulfate) and protein source (soybean meal, low gossypol cottonseed meal, and fish meal) in 16% protein corn-base diets on reproductive performance of sows and performance of their pigs to 21 days of age. Rations were fed at the rate of 4 lb per head per day for an average of 42 days prepartum and ad libitum for 21 days postpartum. Beet pulp was substituted for 2.5% corn during the lactation period.

Six randomly selected pigs were bled at birth and at 3 weeks and one half of these pigs were injected with 100 mg of iron dextrin at one day of age. In addition, one pig was sacrificed at birth to obtain liver samples. No attempt was made to prevent access to the sows' feces during the nursing period.

Table 2 presents a summary of sow and pig performance. Sows fed the cottonseed meal diets farrowed more total and more live pigs than did sows on the other diets. Sows fed the soybean meal diets farrowed and weaned fewer pigs than those fed the other protein sources. Hemoglobin and hematocrit levels at birth were lowest in pigs from sows fed soybean meal, but the levels at three weeks were similar for the three protein sources.

Sows fed diets with added iron farrowed and weaned more pigs than sows on the other diets without added iron. Hematocrit and hemoglobin levels at birth were unaffected by iron treatment, but at 3 weeks they were higher in pigs from sows fed diets with added iron. Hemoglobin and hematocrit levels and weight at 3 weeks were improved by injecting pigs with iron dextrin at one day of age.

Table 2. — Reproductive Performance of Sows and Performance of Pigs as Affected by Protein Source and Iron Levels Fed the Sow, With and Without Injectable Iron to the Pig (Experiment 2)

	Protein Source			Added Iron (sow)		Injected Iron (pig)	
	SBM	CSM	FM	0	700 ppm	100 mg	0
Birth							
Total pigs	8.08	9.75	9.17	8.77	9.22		
Live pigs	7.08	9.50	8.67	8.22	8.61		
Av wt, lb	2.93	3.00	3.16	3.11	2.95		
Hematocrit, %	29.85	33.68	35.85	33.17	33.08		
Hemoglobin, gm/100 ml	7.73	9.58	9.93	9.00	9.16		
3 Weeks							
No. pigs	4.25	5.50	6.17	5.00	5.61		
Av wt, lb	10.44	9.76	10.70	10.41	10.19	10.73	9.88
Hematocrit, %	29.15	30.34	29.83	27.64	31.90	33.00	26.54
Hemoglobin, gm/100 ml	8.24	8.58	7.93	7.40	9.09	9.35	7.15

EFFECT OF DIETARY FAT, PROTEIN, CHOLESTEROL AND ASCORBIC ACID ON SERUM AND TISSUE CHOLESTEROL AND SERUM LIPIDS IN SWINE

R. I. Hutagalung, G. L. Cromwell, V. W. Hays, and C. H. Chaney

Three experiments involving 132 pigs were conducted to study the effects of dietary fat, protein, cholesterol, and ascorbic acid on performance, serum and tissue cholesterol, and serum lipids of swine.

In experiment 1, the addition of 5% lard or tallow to a 12% protein diet increased serum and tissue cholesterol and serum lipid levels, whereas the addition of 5% corn oil elevated only serum lipids. Serum cholesterol and lipids (mg/100 ml) of pigs fed diets with 0 or 5% corn oil, lard, beef or sheep tallow were, respectively: 96, 90, 106, 136, 130; 178, 197, 205, 229, 227.

In experiments 2 and 3, diets containing 13% (diets 1 and 2) or 19% (diets 3 and 4) protein and containing 0% (diets 1 and 3) or 12.5% (diets 2 and 4) added lard were compared. Pigs fed the higher protein levels had lower serum and tissue cholesterol and serum lipid levels than those fed the low protein diets. Fat addition tended to elevate serum cholesterol and serum lipids, l. dorsi and liver cholesterol, and to depress backfat cholesterol at both protein levels. The addition of 1% cholesterol to the diet elevated serum, l. dorsi and liver cholesterol levels, particularly in diets containing added fat, as compared with a 13% protein control diet. The addition of 1100 ppm ascorbic acid to a diet containing 1% cholesterol and 12.5% fat reduced serum and tissue cholesterol and serum lipid levels.

Diet and pooled means of experiments II and III for serum cholesterol (mg/100 ml.); l. dorsi, liver and backfat cholesterol (mg/gm); and serum lipids (mg/100 ml) were respectively: (1) 130, 0.45, 3.58, 1.03, 227; (2) 193, 0.51, 3.97, 0.80, 309; (3) 120, 0.42, 3.27, 1.01, 195; (4) 170, 0.45, 3.83, 0.79, 243; (1 + 1% cholesterol) 197, 0.50, 3.97, 1.08, 242; (2 + 1% cholesterol) 296, 0.55, 4.75, 0.85, 349; (2 + 1% cholesterol + 1100 ppm ascorbic acid) 206, 0.48, 4.22, 0.84, 324.

Gains and feed conversions were improved by feeding higher protein levels and by adding fat but were not consistently affected by dietary cholesterol or ascorbic acid.

HIGH PROTEIN RATIONS FOR SWINE

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

A trial was conducted to determine the effect of feeding excess levels of dietary protein on performance of growing-finishing pigs. Twelve pigs were fed diets containing 16.0, 25.5 or 42.7% protein for 81 days. Percent of corn and soybean meal in the diets and performance of pigs are presented in the following table.

Pigs fed a diet of equal parts of corn and soybean meal performed similarly to those fed a 16% protein control diet; however, gains and feed conversions were depressed by feeding the soybean meal diet. One pig fed the 25.5% protein diet died; however, the cause of death could not be associated with diet treatment. No toxic symptoms were attributed to the excess protein levels although diarrhea occurred throughout the experiment in pigs fed the soybean meal diet. Pigs fed 25.5% protein had diarrhea during the first few days of the trial.

Table 1. — Performance of Pigs Fed Diets Containing Different Percentages of Corn and Soybean Meal

Protein Level, %	16.0	25.5	42.7
Corn, %	75.20	48.55	—
Soybean Meal (44%), %	21.90	48.55	97.10
Mineral-Vitamin Mix, %	2.90	2.90	2.90
No. pigs	4	4 ^a	4
Av. initial wt. (lb.)	55.4	52.5	52.5
Av. final wt. (lb.)	201.6	192.0	173.2
Av. daily gain (lb.)	1.81	1.72	1.49
Av. daily feed (lb.)	5.59	5.66	5.01
Feed per lb. gain (lb.)	3.09	3.28	3.28

^aOne pig died after 40 days on test.

This trial was conducted to illustrate that one can feed levels of protein well above current recommendations without serious detrimental effects to the animals.

PROTEIN LEVELS FOR GROWING-FINISHING PIGS ON CONCRETE

J. R. Overfield and C. H. Chaney

One hundred Yorkshire pigs averaging approximately 50 pounds were used to evaluate protein levels needed for maximum gain and efficiency during the growing-finishing stage. Four replicate lots of 5 pigs each were fed each of 5 protein combinations. The level of protein fed at each stage of the growth period and the overall rate of gain and efficiency of feed conversion are presented in the following table.

Table 1. — Gains and Efficiency of Feed Conversion of Pigs Fed Different Levels of Protein at Different Stages of Growth

Weight Range	Level of Protein, %				
50-75 lb.	18	16	16	14	14
75-100 lb.	16	16	14	14	12
100-125 lb.	16	14	14	14	12
125-Market	14	14	12	14	10
Average Daily Gain, lb.	1.74	1.77	1.73	1.83	1.57
Feed/Gain	3.32	3.29	3.27	3.25	3.70

Maximum gains and most efficient conversion were obtained by feeding 14% protein from 50 pounds to market weight. Reducing the protein level to 12% at 75 pounds and further reducing it to 10% at 125 pounds resulted in a marked reduction in rate of gain and an increase in the feed required per unit of gain.

A COMPARISON OF OPAQUE-2 AND NORMAL CORN FOR PIGS

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

Thirty-two Yorkshire pigs averaging 30 lb were used in a 2 x 4 factorial experiment to compare opaque-2 and normal corn in diets containing 0, 8, 16, and 24% dehulled soybean meal. Since the opaque-2 corn contained a higher protein level than normal corn (9.8 vs. 8.3%), equal parts of cerelose and starch were added to the opaque-2 corn to reduce its protein content to that of normal corn.

All diets were supplemented with adequate levels of vitamins, minerals, and antibiotics. The protein levels of the diets containing 0, 8, 16, and 24% soybean meal were 7.9, 11.1, 14.4, and 17.6%, respectively. Each diet was provided ad libitum for 28 days to 4 pigs housed individually in cages with expanded metal floors.

Pigs fed the opaque-2 diets gained significantly faster and more efficiently ($P < .05$) than those fed the normal corn diets (1.14 vs. 1.02 lb/day; 2.76 vs. 3.08 lb feed/lb gain). The magnitude of difference between the two corns was greater at the lower protein levels. A significant ($P < .01$) quadratic improvement in gain and a significant ($P < .01$) cubic improvement in feed conversion occurred as dietary protein was increased from 7.9 to 17.6%. A significant ($P < .01$) corn x protein interaction was found for feed conversion but not for gain.

COMPARISON OF FREE-CHOICE AND COMPLETE-MIXED RATIONS FOR GROWING-FINISHING SWINE

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

Forty-eight S. P. F. Yorkshire pigs were used to compare the feeding of free-choice and complete-mixed rations to growing-finishing pigs. Three replicate pens of 4 pigs each were fed complete-mixed corn-soybean meal diets or shelled corn and a fortified soybean meal supplement from approximately 40 to 200 pounds bodyweight, or were started on the complete-mixed diets and switched to the free-choice diet at 80 or 120 pounds bodyweight. The protein level of the complete-mixed diet was reduced from 16% to 13% when pigs averaged 120 pounds.

Table 1. — Free Choice vs Complete Mixed Rations for Growing-Finishing Pigs

Complete-Mixed Free-Choice	Approximate Weight Range			
	to 200 lb. ---	to 120 lb. 120 to 200 lb.	to 80 lb. 80 to 200 lb.	--- to 200 lb.
No. pigs	12	12	12	12
Av initial wt (lb)	40.9	41.8	41.4	41.3
Av final wt (lb)	202.7	204.1	204.3	201.6
Av daily gain (lb)	1.67	1.66	1.54	1.54
Av daily feed (lb) complete mix	5.46	4.51	3.91	
corn		5.39	4.85	4.27
supplement		.79	.91	.97
Feed per lb gain (lb)	3.27	3.27	3.43	3.41

Pigs fed the complete-mixed rations from 40 to 120 pounds or from 40 to 200 pounds performed similarly and had faster and more efficient gain than those fed complete-mixed rations from 40 to 80 pounds or those fed the free-choice ration throughout the experiment.

INTERRELATIONSHIPS OF COPPER AND MOLYBDENUM ON PERFORMANCE OF GROWING-FINISHING PIGS

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

Copper and molybdenum interactions in ruminant animals have been known since it was shown that scouring of cattle, caused by excessive intake of molybdenum, could be prevented by copper sulfate and that copper retention in sheep and cattle could be limited by molybdenum in the presence of adequate sulfate. At the present time there is not sufficient research to determine whether or not this interrelationship also exists in swine. The present experiment was designed to study the interrelationships between copper and molybdenum in growing-finishing pigs.

Eighty Yorkshire and Hampshire pigs averaging 52 pounds were assigned by weight and sex to 10 dietary treatments with two replicate lots of four pigs each. A corn and soybean basal diet containing 16 percent protein and supplemented with the necessary vitamins and minerals was used. A 3 x 3 factorial arrangement of treatments was used to compare 3 levels each of added copper (0, 250 ppm, and 500 ppm) from copper sulfate and molybdenum (0, 50 ppm, and 100 ppm) from ammonium molybdate. A tenth treatment containing 500 ppm of copper and 200 ppm of molybdenum was included. All rations contained 1000 ppm of added sulfate provided by copper sulfate, sodium sulfate, and potassium sulfate. Feed and water were allowed ad libitum. Blood samples were taken by anterior vena cava puncture for hemoglobin and hematocrit determinations at the start, fourth week, and termination of the experiment. The experiment lasted 55 days, at which time a Yorkshire barrow from each pen was slaughtered. The middle lobe of the liver and a section from the longissimus dorsi were removed and frozen for later copper and molybdenum analysis.

The average daily gains were similar for pigs fed diets containing 0 and 250 ppm added copper (1.80 and 1.81 lb, respectively), while the 500 ppm copper depressed average daily gains to 1.50 lb. Likewise, the hemoglobin and hematocrit values were similar for pigs fed 0 to 250 ppm copper (13.9 gm/100 ml and 40.7% vs. 13.9 gm/100 ml and 40.2%), whereas 500 ppm copper depressed hemoglobin to 10.7 gm/100 ml and hematocrit to 31.8%. Molybdenum showed very little protection against the depression of gains, or of hemoglobin or hematocrit values caused by feeding the high copper levels.

LEVELS OF PHOSPHORUS FOR GROWING-FINISHING PIGS

C. H. Chaney, G. L. Cromwell, and J. R. Overfield

Two experiments involving 120 SPF Yorkshire pigs were conducted to compare three levels of dietary phosphorus in corn-soybean meal diets for pigs from approximately 46 to 200 lb bodyweight. Phosphorus levels of 0.375, 0.500, and 0.625% and calcium levels of 0.65% were fed to a mean pig weight of 100 lb, after which the phosphorus levels were lowered to 0.3, 0.4, and 0.5% and the calcium levels to 0.5%, respectively.

Dietary protein also was reduced from 16 to 13% at a mean pig weight of 100 lb. Di-calcium phosphate and calcium carbonate were used to adjust the calcium and phosphorus levels.

In both experiments, pigs fed the high phosphorus level gained significantly faster ($P < .01$), and pigs fed the low phosphorus level gained significantly slower and less efficiently ($P < .01$) than those fed the medium phosphorus level. Bone calcium, phosphorus, and ash, and serum phosphorus increased linearly ($P < .05$) and serum calcium decreased linearly ($P < .05$) with increasing increments of dietary phosphorus.

Results for pigs fed the low, medium, and high level of dietary phosphorus were: average daily gain (lb) (Exp. I) 1.37, 1.59, 1.68; (Exp. II) 1.47, 1.65, 1.75; feed per lb gain (lb.) (Exp. I) 3.61, 3.42, 3.33, (Exp. II) 3.57, 3.32, 3.35; bone ash (%) 56.67, 61.32, 62.74; bone phosphorus (%) 6.41, 7.25, 7.59; bone calcium (%) 11.00, 12.84, 12.88; serum phosphorus (mg/100 ml) 7.50, 8.07, 8.28; serum calcium (mg/100 ml) 11.20, 9.84, 9.88; serum alkaline phosphatase (Sigma units/ml) 4.56, 4.27, 4.13.

Barrows gained significantly ($P < .01$) faster (1.67 vs. 1.50 lb/day) but with similar efficiency of feed conversion as gilts (3.45 vs. 3.40 lb feed/lb gain). Compared with barrows, gilts tended to have higher levels of bone ash (60.85 vs. 59.64%) bone phosphorus (7.25 vs. 6.92%), bone calcium (12.52 vs. 11.96%) and serum calcium (10.92 vs. 9.70 mg/100 ml), but lower serum phosphorus (7.82 vs. 8.08 mg/100 ml) and serum alkaline phosphatase levels (4.19 vs. 4.45 Sigma units/ml).

Carcass traits were not significantly ($P < .05$) affected by dietary phosphorus level. Gilts tended to be longer (29.86 vs. 29.68 in.) with less backfat (1.40 vs. 1.44 in.) and more loin eye area (4.55 vs. 4.14 sq. in.) than barrows.

UTILIZATION OF UREA BY LACTATING DAIRY COWS

H. H. Van Horn and D. R. Jacobson

Urea is simply an economical source of nitrogen. When fed to ruminants, urea can be used by rumen microorganisms in the synthesis of amino acids and protein. These facts concerning urea utilization have been known for some time. However, the point yet to be resolved for lactating dairy cows is the amount of urea that can be used in the cow's ration in place of naturally occurring proteins without depressing milk production. Or, if some depression in milk production occurs, it becomes necessary to find the amount of urea that can be fed under different conditions without depressing milk production to the point that the profit advantage achieved through reduced supplement costs is lost. Protein supplement costs are greatest in high-corn silage rations because of the low-protein level in corn silage.

In the winter of 1967-68, two experiments were conducted with all-corn silage feeding programs. Experiment 1 attempted to measure the milk production responses to different levels of urea in rations containing a high, medium, or low level of crude protein. Experiment 2 measured the milk production response to urea as compared to no protein or nitrogen supplementation.

Experiment 1

Following a 22-day adjustment period, 24 Holstein cows were assigned to four treatments (pens) which represented increments of urea in the ration. These levels were approximately 0, .17, .34, and .51 pound of urea per cow daily for Pens 1, 2, 3, and 4 respectively. The urea was supplied in the concentrate for Pen 2, in corn silage for Pen 3, and in concentrate and silage for Pen 4. All additional protein supplement was supplied by soybean meal. Within each urea treatment (pen), two cows were assigned to each of three levels of crude protein intake, giving a 4 x 3 factorial arrangement of treatments. The three levels of crude protein were achieved by varying the amount of soybean meal fed to individual cows.

These rations were provided to the cows for a 70-day period. The responses to urea levels were variable, with the average daily milk production for the 70-day period being 42.8, 40.4, 37.7, and 48.3 pounds daily for the 0, .17, .34 and .51 pound per day levels of urea (Pens 1, 2, 3, and 4), respectively. The average daily milk productions for the same groups during the preliminary period when all cows received the same rations were: 49.5, 48.6, 48.9, and 51.2 pounds per day, respectively. There were no appreciable differences in milk production due to the level of crude protein in the ration.

Experiment 2

In this experiment, two groups of cows (6 Jersey cows in each group) were used in a double reversal trial comparing milk production obtained with no protein or nitrogen supplementation to a urea-supplemented ration. The basic ingredients in both rations were corn silage and shelled corn. In this study, one group of cows received urea supplementation for 3 weeks, no supplementation for 3 weeks, and urea supplementation for 3 weeks. The other group received no supplement, urea, and no supplement respectively, for the 3-week periods. Milk production was significantly greater on the urea-supplemented ration.

Conclusions

It was definitely demonstrated in Experiment 2 that urea is beneficial in protein deficient rations for lactating cows. However insufficient data have been collected to clearly demonstrate the maximum amount of urea that can be used profitably in rations for lactating dairy cows. Therefore, no changes are suggested at this time in the commonly accepted recommendation that urea levels be limited to 20 percent of the crude protein equivalent of the total ration for high-producing dairy cows.

SULFUR, NITROGEN AND AMINO ACID BALANCE, AND DIGESTIBILITY OF LOW SULFUR AND SULFUR SUPPLEMENTED DIETS FED TO LACTATING COWS

Don R. Jacobson, Bedjo Soewardi, J. W. Barnett,
R. H. Hatton, and S. B. Carr

Eight mature lactating Holstein cows were divided into two groups. The low sulfur group received a concentrate mix containing 0.10% sulfur and the sulfur supplemented group received the same concentrate mix supplemented to contain 0.18%. Both groups were fed the same corn silage (0.09% sulfur, dry basis) and the respective

concentrate mix free choice at a ratio of 6.3 to 1.0. Eighty percent of the ad libitum intake was fed during the balance and digestibility trials.

The low sulfur group excreted significantly less sulfur in urine but not in feces or milk. All cows were in negative sulfur balance, but in positive nitrogen balance. The supplemental sulfur was inefficiently utilized, as indicated by the increased urinary excretion of sulfur and by no effect on sulfur balance. Therefore, inorganic sulfur only partially meets the cow's total dietary sulfur requirement.

There were no differences between groups in apparent digestibility of dry matter, crude fiber, crude protein, nitrogen free extract, ether extract, total digestible nutrients, or energy. Balance of amino acids was very similar for both groups. All animals were essentially in balance for methionine, cystine, and tyrosine, in negative balance for glutamic acid and lysine, and in positive balance for histidine, arginine, aspartic acid, threonine, serine, glycine, alanine, valine, isoleucine, leucine, phenylalanine, and proline.

The data suggest that inadequate rumen synthesis of certain amino acids limits voluntary feed intake and milk production of high producing cows in which 45% of the nitrogen of the diet is non-protein nitrogen.

PROPERTIES OF TOXIC FESCUE EXTRACTS

Suh-Jen Yau and D. R. Jacobson

Eighty percent ethanol extract of toxic Kentucky 31 fescue was diluted with an equal volume of water and dialyzed against water overnight at 4°C. The dialysis extract was concentrated to the original volume and administered to two rats. Intraperitoneal injections of the extract at 26.47g hay equivalent per 100g body weight increased tail skin temperature 3.6°C after 21 min, which was followed by a decrease to below the original. There was a 5.3°C reduction of deep body temperature at 1.75 hours. Purple discoloration (the first sign of necrosis) was noted on the tail the 15th day after extract administration began.

Purification of crude ethanol extract was also done by extraction with a water-chloroform system. The physiologically active factor was always present in the aqueous phase. Intraperitoneal administration to rats gave a response similar to that of the dialysis extract. Occasionally twitching was observed. Death usually occurred after higher dose administration. The toxic principle was water extractable, non-volatile, and heat stable. Paper and thin layer chromatographic studies of the extract revealed properties of polybasic acids.

ESTABLISHMENT OF MICROBIAL ACTIVITY IN PRE-WEANED LAMBS

S. E. Poe, G. E. Mitchell, Jr., P. G. Woolfolk, G. L.
M. Chappell, and W. P. Deweese

Previous trials indicated that lambs could be weaned at 4 weeks of age. The objective of this study was to measure quantitatively the microbial activity of young lambs receiving milk only and milk plus creep.

Procedure

Twenty Hampshire-sired crossbred lambs were randomly allotted to two groups of 10 each at birth. One group received creep free-choice and the other only nursed their dams. All lambs were bedded on tobacco stems so that the milk-fed lambs would not consume their bedding. The ewes were fed separately. Feed consumption and weight gains were measured on all lambs. Rumen samples were taken from each lamb every two weeks to form a composite sample for starch and cellulose digestion *in vitro*. These values were compared to values obtained from composite samples from lambs 10, 12, 14, and 16 weeks old fed a conventional fattening ration (control).

Results and Discussion

The creep-fed lambs nearly tripled their feed consumption every 14-day period (Table 1). After the first 14-day period the creep lambs gained considerably faster than the milk-fed lambs for the remainder of the study. As noted in Table 2 the percentage cellulose digested was similar to that digested by the creep lambs and the controls. The lambs receiving milk only were consuming some of the tobacco stems used for bedding. After they were housed on asphalt for 14 days the starch digestion averaged 6.4% and cellulose 11.5%. This indicated that the consumption of the tobacco stems had not affected starch digestion but had contributed to the development of cellulose digesting activity. Furnishing a creep free-choice promoted development of starch and cellulose digesting activity in pre-weaned lambs as early as 14 days of age.

Table 1. — Feed Consumption and Weight Gains of Lamb

Age in Days	Creep Lambs		Milk Lambs, Gain ^{1/}
	Feed Consumed ^{1/}	Gain ^{1/}	
	kg	kg	kg
1 - 14	2.27	76.7	76.8
15 - 28	7.71	60.5	40.5
29 - 42	19.50	79.5	33.0
43 - 56	60.33	99.5	21.5

^{1/} Group total for each 14-day period.

Table 2. — Percentage Digestion of Starch and Cellulose

Age in Weeks	Creep		Milk		Control	
	Starch	Cellulose	Starch	Cellulose	Starch	Cellulose
	%	%	%	%	%	%
2	43.6	35.4	4.2	23.4	-	-
4	39.1	35.5	5.5	38.6	-	-
6	53.5	40.0	7.3	49.0	-	-
8	46.0	34.5	13.2	33.8	-	-
10	-	-	-	-	48.6	44.5
12	-	-	-	-	42.2	36.2
14	-	-	-	-	59.6	37.0
16	-	-	-	-	36.8	34.2

GROWTH AND DEVELOPMENT OF EARLY WEANED LAMBS

S. E. Poe, H. A. Glimp, W. P. Deweese, and G. E. Mitchell, Jr.

The development of the ruminant stomach has been reported to some degree in the literature. This study was designed to evaluate three pre-weaning rations for the young lamb and the effects of each on growth after weaning.

Procedure

Thirty Hampshire-sired crossbred single ewe lambs were randomly allotted to the following three treatments at birth: (1) milk only; (2) milk plus concentrate creep; and (3) milk plus roughage creep. All lambs were allowed to nurse from 5 p.m. to 8 a.m. and from 12 noon to 1 p.m. daily. Both creep rations were provided free-choice. Weekly feed consumption and weight gains were measured. Two lambs from each treatment were slaughtered at 4, 6, 8, 12, and 16 weeks of age. The following measurements were taken at slaughter: live weight; ingesta-free body weight; volume of submerged reticulo-rumen; and weight of wet tissue from each stomach compartment. Samples taken from stomach contents at slaughter were analyzed for pH, volatile fatty acids, ammonia, thiamine, and riboflavin. Blood samples were collected every two weeks and daily for one week after weaning and analyzed for plasma glucose, urea, and total protein levels.

Results and Discussion

Although the pre-weaning consumption of both creep rations was quite low (200 to 500 gm per lamb), lambs on both diets gained significantly faster than the lambs fed milk only. However, no pre-weaning treatment significantly affected post-weaning gains. Rumen development followed the ingestion of dry feed. Little difference was noted in the rumen development of the lambs fed concentrate creep and roughage creep. This can be attributed to the small amounts of pre-weaning creep ingested and the short time the creep was provided. After weaning all lambs were fed the same ration and development followed similar patterns regardless of pre-weaning treatment.

INTAKE AND PERFORMANCE OF YOUNG LAMBS

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

At birth the lamb is essentially a monogasteric animal. After the ingestion of dry feed the rumen develops along with its microbial population. If the objective of three lamb crops in two years is to be reached, a thorough understanding of this free-choice. Each lamb and each ewe were confined individually to a concrete pen bedded with tobacco stems. Each ewe was fed 1 kg of a conventional pelleted ration twice daily.

Procedure

Twenty-four twin, black-faced crossbred lambs were randomly allotted to two groups at birth. One group received only milk and the other received milk plus creep free-choice. Each lamb and each ewe was confined individually to a concrete pen bedded with tobacco stems. Each ewe was fed 1 kg of a conventional pelleted ration twice daily.

The lambs in both groups were allowed to nurse their mothers from 5 p.m. until 8 a.m. and from 12 noon to 1 p.m. daily except during the time when milk production was measured.

Milk production was measured for each ewe. The lamb was given a 5 3/4 - hour fast followed by a 15-minute nursing period. This was done four consecutive times, constituting a twenty-four hour period every two weeks. The lambs were weighed before and after nursing. One lamb from each set of twins was weaned at 4 weeks of age. The weaned lambs in both Group I (milk only) and Group II (milk plus creep) received the creep ration free-choice. The lambs that were not weaned in each group continued on the original treatments and milk intake measurements were made.

Results and Discussion

At the start of this study the 12 lambs in Group I averaged 44.3 kg weight, while those in Group II averaged 45.1 kg. The total gain for each 14-day period is shown for each group in Table 1. The lambs that received milk plus creep from birth and were not weaned gained fastest. Lambs that received creep prior to weaning at 4 weeks made greater 10-week gains than either milk fed group. Although one lamb per set was weaned from each ewe at 4 weeks, milk intake per lamb did not increase greatly and continued to decline over time (Table 2). The lambs that were provided a creep consumed more milk throughout the study. The lambs receiving creep before weaning consumed more feed after weaning until 8 weeks of age, as shown in Table 3. The lambs receiving creep from birth consumed more milk, consumed more total feed, and maintained a higher level of performance throughout this study.

Table 1. — Influence of Early Weaning and Creep Feeding on Lamb Gains^{a/}

Age in Days	Milk Only		Milk Plus Creep	
	Milk kg	Milk ^{b/} kg	Milk plus creep kg	Milk plus creep ^{b/} kg
0 - 14	20.7	18.2	19.8	20.3
15 - 28	21.8	16.5	24.7	25.3
29 - 42	28.8	16.6	32.2	20.5
43 - 56	23.4	25.4	27.8	26.5
57 - 70	17.6	25.0	26.2	25.5
Total	112.4	101.8	130.7	118.1

^{a/} Total for 6 lambs per treatment

^{b/} Weaned at 28 days of age

Table 2. — Milk Intake of Lambs by Groups^{a/}

Age in Days	Milk Only		Milk Plus Creep	
	Milk	Milk ^{b/}	Milk plus creep	Milk plus creep ^{b/}
	kg	kg	kg	kg
0 - 14	1.2	1.1	1.3	1.2
15 - 28	1.0	0.9	1.2	1.3
29 - 42	1.2	-	1.5	-
43 - 56	1.0	-	1.3	-
57 - 70	0.9	-	1.0	-
Total	4.5	2.0	6.3	2.5

^{a/} Average of 6 lambs per treatment

^{b/} Weaned at 28 days of age

Table 3. — Feed Consumed by Young Lambs^{a/}

Age in Days	Milk Only		Milk Plus Creep	
	Milk	Milk ^{b/}	Milk plus creep	Milk plus creep ^{b/}
	kg	kg	kg	kg
0 - 14	-	-	0.6	.5
15 - 28	-	-	3.3	4.6
29 - 42	-	32.5	9.5	42.4
43 - 56	-	71.0	24.1	82.3
57 - 70	-	97.1	43.5	99.4
Total		200.6	81.0	229.2

^{a/} Total of 6 lambs per treatment

^{b/} Weaned at 28 days of age

PERFORMANCE AND CARCASS CHARACTERISTICS OF EARLY WEANED LAMBS SLAUGHTERED AT DIFFERENT WEIGHTS

H. A. Glimp, W. P. Deweese, J. D. Kemp, and L. K. Stone

There appears to be a trend toward marketing lambs at heavier weights. Retail merchandisers accept heavier carcasses provided they are meatier. Some experimental data suggests a high positive relationship between weight of lamb and amount of fat. The following experiment was designed to correlate the performance of lambs slaughtered at different weights with the loin eye area, percent fat in the rack, and the fat thickness over the 12th rib.

Procedure

Seventy-two Hampshire-sired wether lambs out of Northwestern crossbred ewes were weaned at approximately 18.1 (40 lb) kilograms and assigned to groups of 24 lambs each to be slaughtered at live weights of 36.2, 45.3, and 54.4 kilograms (80,

100, and 120 lb). These lambs were fed a high concentrate pelleted ration in pens of three lambs each. 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.

Results and Discussion

Average daily gains reached a maximum of .355 kg from 36.2 to 45.3 kg bodyweight, and declined to 0.281 kg from 45.3 to 54.4 kg bodyweight (Table 1). Feed efficiency decreased from 3.66 kg feed/kg gain for the 18.1 to 27.2 kg period, to 8.08 for the 45.3 to 54.4 kg growth period. Total gains from 18.1 to 54.4 kg required 5.50 kg feed/kg gain.

Loin-eye area and fat thickness measurements were, respectively: 14.2 sq cm, 0.51 cm (36.2 kg lambs); 15.8 sq cm, 0.74 cm (45.3 kg lambs), and 16.0 sq cm, 1.19 cm (54.4 kg lambs). These data suggest that most of the muscle development occurred in these lambs prior to 45.3 kg bodyweight.

Performance of lambs from 18.1 to 54.4 kg was negatively correlated with percent fat in the rack and backfat thickness (- 0.59** and - 0.51**, respectively). Correlations between loin-eye area and lamb performance were low and non-significant. Since gains for lambs over 45.3 kg (100 lb) were much less efficient than earlier gains and appeared to consist primarily of fat, feeding lambs of this type to heavier weights does not seem advisable.

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

Weight		Average Daily Gain	Feed/gain
kg	kg	kg	kg
Birth - 18.1		0.294	-
18.1 - 27.2		.299	3.66
27.2 - 36.2		.344	4.82
36.2 - 45.3		.355	5.64
45.3 - 54.4		.281	8.08

Table 2. — Correlation between Performance and Carcass Measurements

	Loin-eye Area	Percent Fat in Rack	Backfat Thickness
ADG, 18.1 - 36.2 kg	0.28	- 0.01	- 0.002
Slaughter wt., 36.2 kg	- 0.20	0.08	0.01
ADG, 18.1 - 45.3 kg	0.27	- 0.12	- 0.03
Slaughter wt., 45.3 kg	- 0.40*	0.30	0.05
ADG, 18.1 - 54.4 kg	0.05	0.49**	- 0.50**
Slaughter wt., 54.4 kg	- 0.14	0.59**	0.51**

*P < 0.05

**P < 0.01

INFLUENCE OF VITAMIN A DEFICIENCY ON RENAL FUNCTION IN EWES

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

Vitamin A metabolism has been studied by researchers for several decades. Previous Kentucky studies with vitamin A-deficiency in sheep have revealed rather marked changes in plasma and urine composition in the deficient state. An apparent preferential uptake of vitamin A by adrenal glands of vitamin A-deficient sheep has also been observed. The experiments reported here were designed to obtain additional information concerning the renal function of sheep during and following vitamin A depletion.

Procedure

Fourteen ewes were used in these experiments to study the influence of vitamin A deficiency on the renal function parameters of glomerular filtration rate (GFR) and renal plasma flow (RPF). Creatinine clearance was used to estimate GFR and p-aminohippuric acid clearance was used to estimate RPF. In addition, the clearances of urea and phosphate were observed. Each ewe was fed 908 gm per day of a carotene-deficient ration composed of ground corncobs, ground milo, and soybean meal. Supplemental vitamin A palmitate (3122 I.U./kg) was added to the ration of seven of the ewes.

Results and Discussion

After two months liver levels of vitamin A were lower ($P < .05$) in the group fed the unsupplemented ration (30.2 vs. 54.1 mcg/gm) while plasma levels (27.7 vs. 32.2 mcg/100 ml) were not significantly different. Renal clearances of creatinine, PAH, urea and phosphate were not significantly affected. After 21 months plasma vitamin A (4.7 vs. 35.3 mcg/100 ml) was significantly lower ($P < .01$) in the group fed the unsupplemented ration. Both creatinine and PAH clearances were lower ($P < .05$) in this group, indicating decreased glomerular filtration rate and renal plasma flow, respectively. Urea clearance was also decreased ($P < .05$) by vitamin A deficiency. Phosphate clearance was elevated but the difference was not significant.

Renal clearances were not significantly affected during early vitamin A depletion but were significantly altered after vitamin A stores were fully depleted.

BILIARY SECRETION OF METABOLITES OF VITAMIN A AND BETA-CAROTENE IN SHEEP

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

Radioactivity was observed in the feces of steers and lambs injected intravenously with tritium-labeled vitamin A in earlier experiments at Kentucky. These data suggested that metabolites of vitamin A could have been secreted into the gastrointestinal tract via the bile. The following experiments were conducted to investigate possible biliary secretion of metabolites of vitamin A and beta-carotene in the ruminant.

Procedure

The common bile ducts of sheep were cannulated with 2 mm I. D. plastic tubing. Re-entry cannulae were placed in the small intestine near the juncture of the bile duct and small intestine. All sheep were injected intrajugularly with either ^3H -vitamin A acetate or ^{14}C -beta-carotene in an aqueous solution of 20% polyoxyethylene sorbitan monooleate (Tween 80). Total bile was collected at timed intervals with a fraction collector for 24 hours after injection.

Results and Discussion

In three trials, 35.5 μC of ^3H -vitamin A acetate with a specific activity of 213 $\mu\text{C}/\text{mg}$ were injected intravenously. An average of 21.4% of the injected radioactivity appeared in the bile during the following 24-hr intervals. In duplicate trials, 4.4 μC of ^{14}C -beta-carotene with a specific activity of 13.2 $\mu\text{C}/\text{mg}$ were injected intravenously. During the ensuing 24-hr interval, an average of 16.4% of the injected radioactivity was secreted into the bile. In a third trial, 20.0% of the injected radioactivity appeared in the bile during a 21.5-hr collection period.

These data suggest that secretion of vitamin A metabolites in the bile is of major importance in the vitamin A metabolism of ruminants. Further experiments have been initiated in an attempt to characterize the metabolites secreted, to study the re-absorption of the metabolites, and to determine their biological potency.

LOSSES OF VITAMIN E FROM THE PRE-INTESTINAL DIGESTIVE TRACT OF STEERS

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

Recent reports of increased gains with supplemented vitamin E in steers fed no-hay finishing rations and the role of vitamin E in protecting milk from oxidized flavors have increased interest in vitamin E utilization by ruminants. Vitamin E is closely associated with vitamin A in its solubility in fat, its distribution in fatty tissues in the body, and its role in protecting vitamin A from oxidative destruction. Extensive pre-intestinal disappearance of vitamin A has been demonstrated in both cattle and sheep, and destructive activity in the rumen and abomasum is probably the major factor in this disappearance. If vitamin E is affected in a similar manner, pre-intestinal action on dietary vitamin E might exert a major influence on the vitamin E status of ruminants. The experiments reported here were designed to study possible pre-intestinal loss of vitamin E in steers fed different levels of concentrates.

Procedure

Four mature steers fitted with permanent abomasal fistulas were each fed 5 kg per day of rations containing 20, 40, 60, and 80 percent corn in ascending then descending order of corn content, with two observations per steer in each of eight 22-day treatment periods. After a 13-day preliminary period for each ration, each steer was treated on the 14th day and 21st day with 20,000 I.U. alpha-tocopherol, 1,000,000 I.U. vitamin A in 19 ml aqueous tween "80", 20 gm chromic oxide and 20 gm polyethylene glycol (M.W. 4000) in gelatin capsules. Abomasal collections, taken

before treatment and 24 hours after treatment, were analyzed in triplicate for vitamin E, chromic oxide, and polyethylene glycol.

Percent disappearance of vitamin E was estimated from weighted averages of ratios of vitamin E to chromic oxide and polyethylene glycol in abomasal contents 24 hours after administering vitamin E.

Results and Discussion

Disappearance of vitamin E averaged 8.4, 22.2, 25.0, and 42.4% for the 20, 40, 60, and 80% rations, respectively. Except for the difference between the 40% and 60% rations, all differences between individual rations were significant ($P < .02$). The data indicate that large portions of vitamin E administered orally to steers fail to reach the small intestine. Adding grain to the ration appears to increase this disappearance.

EFFECT OF CONCENTRATE LEVEL ON PRE-INTESTINAL DISAPPEARANCE OF VITAMIN A

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

Results of previous experiments have indicated that there may be considerable destruction of the ingested vitamin A before it reaches the small intestine. High concentrate rations are most likely to require vitamin A supplementation. Since level of concentrate in the ration affects rumen fermentation, it seems possible that it could affect destruction of vitamin A in the rumen. This report gives the results of an experiment conducted to study this possibility.

Procedure

Four mature steers with permanent abomasal fistulas were fed four alfalfa, corn, soybean meal rations, containing 20, 40, 60, and 80% corn and balanced for protein, calcium, phosphorus, and vitamin A, in ascending order and then in descending order of corn content. Each steer was fed 2.5 kg twice daily. A 2-week preliminary period was followed by two recovery trials one week apart and then the rations were changed.

Pre-intestinal disappearance of vitamin A was estimated by administering approximately 1,000,000 I.U. of vitamin A acetate dispersed in 19 ml of 20% aqueous tween "80", 20 grams of chromic oxide and 20,000 I.U. of vitamin E in gelatin capsules. Twenty-four hours after dosing, abomasal contents were collected through the abomasal fistula and analyzed in triplicate for vitamin A and chromic oxide. Changes in the ratios of chromic oxide to vitamin A from the ratio administered were used to estimate percentages of administered vitamin A reaching the abomasum.

Results and Discussion

Calculated pre-intestinal disappearances of vitamin A averaged 52.2% for the 20% corn ration, 55.9% for the 40% corn ration, 70.1% for the 60% corn ration, and 62.2% for the 80% corn ration. Disappearances in steers fed 20 or 40% corn were within ranges previously observed for all roughage rations and were not significantly

different. Other differences were highly significant ($P < .01$). It appears from these data that pre-intestinal disappearance of vitamin A is likely to increase when corn is added at levels above 40%. Greatest disappearance was observed at 60% corn and no further increase was observed when corn was increased to 80%. Thus, the increased need for vitamin A supplementation as rations for feedlot cattle are increased in grain content may be accompanied by decreased efficiency of utilization of oral vitamin A.

EFFECTS OF IODINATED CASEIN AND TAPAZOLE ON VITAMIN A TURNOVER IN STEERS

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

Previous work has demonstrated continuous turnover of vitamin A stores but little is known concerning the mechanisms controlling vitamin A turnover. Thyroid activity is known to play an important role in the regulation of metabolic processes. This is the first of a series of experiments planned to determine the relationships between thyroid function, metabolic rate, and growth rate on turnover of vitamin A in the liver of steers.

Procedure

Six 400 kg Hereford steers having previously established liver stores of tritium-labeled vitamin A were divided into two groups and fed either 10 gm per steer per day of iodinated casein or 0.5 gm per steer per day of tapazole (1-methyl-2-mercaptoimidazole) in a basal ration containing 3.6 kg alfalfa hay, 3.6 kg ground shelled corn, and 40,000 I.U. of vitamin A palmitate. Liver samples taken by aspiration biopsy at 21-day intervals were assayed for vitamin A and tritium activity. Vitamin A turnover rate was then estimated from changes in liver specific activity (DPM per mcg vitamin A). Blood serum taken by jugular puncture at the time of biopsy was analyzed for protein bound iodine.

Results and Discussion

Mean serum protein bound iodine increased from 6.3 mcg per 100 ml serum prior to treatment to 36.6 mcg per 100 ml serum for steers receiving iodinated casein, and 14.9 mcg per 100 ml serum for steers receiving tapazole. Liver vitamin A remained relatively constant throughout the period of the experiment. The average half-time of vitamin A in this experiment was estimated to be 212 ± 44 days in steers receiving iodinated casein and 93 ± 11 days in steers receiving tapazole.

SULFOBROMOTHALEIN (BSP) EXCRETION BY SHEEP DURING METABOLIC STRESS

R. E. Tucker, G. E. Mitchell, Jr., and C. O. Little

Sudden introduction of large amounts of grain into ruminant rations results in severe rumen dysfunction and a variety of physiological stresses. Since the liver has a central role in the metabolism of many of the compounds potentially responsible for these stresses, liver function might be an important factor determining the ability of

the animal to adjust to the introduction of grain into ruminant rations. BSP clearance has been widely used in human medicine as a general test of liver function. This test has been adapted to sheep and used as a criterion of liver function during metabolic stress.

Procedure

After calibration of dosage levels and verification of biliary excretion of the dye, BSP clearance rates were determined before and at selected intervals after administering the following treatments to wethers: (1) intraruminal injection of 20 ml of carbon tetrachloride to produce liver damage, (2) intravenous infusion of sodium nitrite, (3) inducing rumen acidosis by overfeeding grain, (4) intravenous infusion of glucose, and (5) intravenous infusion of sodium lactate.

Results and Discussion

BSP clearance rates were greatly reduced by poisoning the liver with carbon-tetrachloride or inducing anoxia by infusion of sodium nitrite. This indicates that the test is sensitive to certain types of liver dysfunction in sheep. In most animals, overfeeding or infusing either glucose or sodium lactate to simulate certain aspects of overfeeding stress increased BSP clearance 24 and 48 hours after introduction of stress. These results provide no evidence of liver dysfunction associated with the rumen dysfunction induced by overfeeding grain.

PROTEIN STATUS OF SHEEP AND LEVELS OF BLOOD ACETATE AND GLUCOSE

J. W. McAtee, C. O. Little, and G. E. Mitchell, Jr.

Acetate and glucose are products of carbohydrate digestion that appear in the systemic blood of ruminants in greatest quantities. There have been reports that clearance of these metabolites from the blood of ruminants maintained on a low-protein ration is decreased. The level of energy intake is known to have an effect on nitrogen balance. This work was conducted to study the relation of energy and nitrogen metabolites in the blood of sheep.

Procedure

Mature wethers weighing 50 kg with abomasal fistulas were used in a series of three experiments. The animals were maintained on a low-protein, high-fiber ration. The protein status of the wethers was altered by infusion of 72 gm soybean protein into the abomasum and blood levels of the energy metabolites were elevated by abomasal infusions of 50 gm acetate or 50 gm glucose. Samples of jugular blood were collected immediately before treatment and 1, 2, 3, and 4 hours after infusions. Plasma levels of amino nitrogen, urea nitrogen, acetate, and glucose were determined.

Results and Discussion

Infusion of protein into the abomasum of wethers had no effect on normal levels of blood glucose and further increased elevated levels of blood glucose. Abomasal

infusion of protein resulted in a lowering of both normal and elevated levels of plasma acetate. Protein infusion markedly elevated plasma free amino nitrogen and slightly increased plasma urea nitrogen. Abomasal infusions of either acetate or glucose decreased both normal and elevated levels of plasma amino nitrogen but did not consistently affect plasma urea nitrogen levels.

The results suggest important relationships among energy and nitrogen metabolites in the blood. Balance of these metabolites may be of importance in determining clearance rates.

POST-RUMINAL CELLULOSE DIGESTION IN SHEEP

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

Rumen microorganisms are responsible for much of the cellulose digestion in the ruminant. However, sizable amounts of cellulose are not digested in the rumen. This report gives the results of an experiment conducted to study the extent of post-ruminal cellulose digestion.

Procedure

Seven wethers, weighing between 27 and 34 kg and previously fitted with permanent abomasal fistulas, were fed two isonitrogenous rations differing in concentrate level. The high concentrate ration contained 92.5% cracked corn and analyzed 6% cellulose. The roughage ration contained 40% corn, 53% ground alfalfa hay, and analyzed 22.2% cellulose. The lambs were maintained in metabolism stalls and fed either 250 or 300 gm twice daily, depending on body weight. After two-week preliminary periods, 30 gm of purified wood cellulose mixed in a water slurry was infused into the abomasum twice daily 2 hours after feeding for 12 days. Total fecal samples were collected during the last 6 days and analyzed for cellulose. Post-ruminal digestion of the administered cellulose was estimated by difference technique using each lamb as its own control when no cellulose was administered. Samples were also taken through the abomasal fistula during the control period and analyzed for cellulose and chromic oxide. Cellulose of ration origin reaching the abomasum and the administered cellulose were used in calculating total post-ruminal cellulose digestion.

Results and Discussion

Percent post-ruminal digestion was similar with both rations. The lambs fed the roughage ration averaged 33.2% digestion of administered cellulose in the lower gastro-intestinal tract. Post-ruminal cellulose digestion for the lambs fed the concentrate ration averaged 36.5%. Total post-ruminal cellulose digestion during cellulose infusion averaged 200 for the roughage ration and 192 gm for the high concentrate ration.

The data indicate a significant role for the post-ruminal digestive tract in cellulose utilization by sheep. There was little indication that level of concentrate in the ration influences the ability of sheep to digest cellulose posterior to the rumen.

RUMEN METABOLITE UTILIZATION BY MATURE RATS

J. W. McAtee, C. O. Little, and G. E. Mitchell, Jr.

Acetate, propionate, and butyrate are metabolites produced during fermentation of carbohydrates in the rumen. These compounds become available as energy sources to the ruminant and their utilization contributes to the efficiency of animal production. Previous research reports have supported the use of laboratory animals to study the utilization of these metabolites more intensively and have summarized results with young weanling rats. The utilization of energy from acetate, propionate, and butyrate was studied with mature rats in this experiment.

Procedure

Short chain fatty acids in the form of their triglycerides were substituted for starch and glucose to provide 24% of the gross energy of the ration for adult rats. Glycerol content was equalized to compensate for the glycerol in the triglycerides. The rations were offered in quantities to provide 0.75 kcal per gm metabolic body weight daily with feed adjustments made at 5-day intervals. Digestible and metabolizable energy were determined from a 5-day collection of feces and urine with 4 animals per treatment. Body gain and energy balance were measured in 7 animals per treatment during a 20-day feeding period.

Results and Discussion

The results are summarized in Table 1. Body weight gain was lower for rats fed the ration containing butyrate. Although highly variable, protein and fat content of the carcasses of rats fed the control ration containing starch and glucose tended to be higher than with the rations containing acetate, propionate, or butyrate. The energy of rations containing these rumen metabolites digested and metabolized as well as the energy of the control ration. Net energy values indicated no significant differences in the utilization of metabolizable energy from the different sources.

Table 1. — Utilization of Rumen Metabolites by Rats

	Control	Acetate	Propionate	Butyrate
Body gain, gm	33	32	33	24
Carcass comp., % DM				
Protein	56	50	47	47
Fat	32	23	19	20
Digestible energy, %	94	93	94	93
Metabolizable energy, %	90	89	90	90
20-day ave. intake,				
Kcal metab. energy	796	767	715	733
Net energy				
For gain, kcal	113	99	100	69
For maintenance, kcal	448	432	430	417
Total, kcal	561	531	530	486
% of metab.	70	72	74	68

PROLINE METABOLISM DURING CELLULOSE DIGESTION BY RUMEN MICROORGANISMS

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

The extent of utilization of many feedstuffs by the ruminant is dependent on the activity of the rumen microbial population. It has been established that certain natural feeds and fermentation products increase the utilization of low-quality roughages and nonprotein nitrogen by stimulating rumen microbial activity. However, the specific constituents contained and the nature of these stimulatory properties have not been well defined.

Past work in this area was concerned with fractionation and identification of factors present in feeds which stimulate rumen microbial activity. Results indicated that a major portion of this stimulatory activity in distillers dried solubles was related to a fraction which contained the amino acid proline. Current work has been directed toward studying metabolic mechanisms and rates involved in the rumen microbial response to proline.

Using uniformly labeled C^{14} L-proline, qualitative and quantitative parameters of proline metabolism by rumen microorganisms have been investigated using in vitro procedures. When cellulose digestion was increased 30 to 50% by proline or valeric acid additions, 5- to 7-fold rises in valeric acid levels resulted in tubes to which proline was added. Subsequent disappearance of this valeric acid indicated continued utilization of valeric acid during periods of rapid cellulose digestion. With the addition of labeled proline, 15.2 and 47.1% of the C^{14} activity was recovered in the steam volatile fractions after 12- and 24-hr fermentations, respectively. Cellulose digestion during these two fermentation periods were 12.4 and 30.6%. C^{14} activity was traced into the protein and lipid fractions of microbial cells with only low levels of activity appearing in carbon dioxide.

VOLATILE FATTY ACID CONCENTRATIONS IN RUMINAL FLUID OF STEERS FED CHLORTETRACYCLINE OR TYLOSIN

G. E. Mitchell, Jr., C. O. Little, and L. G. Kennedy

Although major alterations might be expected to affect performance, little attention has been given to the influence of antibiotic feeding on volatile fatty acid (VFA) production in the rumen. This experiment was conducted to study the possible influence of high levels of chlortetracycline and tylosin on VFA concentrations in ruminal fluid.

Procedure

Four mature steers with rumen fistulas were used in two simple reversal trials. Each steer was fed 3.63 kg (8 lb) of alfalfa hay and 0.45 kg (1 lb) of ground shelled corn twice daily throughout both trials. In the first trial two steers assigned at random received 500 mg of chlortetracycline mixed with the corn daily for 22 days, while the other two steers served as controls. The antibiotic treatment was then discontinued for one week before reversing the treated and control steers for the next 22 days. Samples of ruminal fluid were taken on two consecutive days before neomycin sulfate feeding was started, and on days 1, 2, 7, 8, 14, 15, 21 and 22 after treatment began.

These samples were analyzed for acetic, propionic, butyric, valeric, and isovaleric acids by gas chromatography. The second trial was conducted in a similar manner with 500 mg per head per day of tylosin phosphate replacing chlortetracycline as the antibiotic.

Results and Discussion

The results are summarized in terms of total VFA concentrations and acetate: propionate ratios in Table 1. Since consistent post-treatment trends were not apparent, all post-treatment values were averaged. In agreement with previous results obtained from feeding bacitracin and neomycin, there was little indication of shifts in VFA production in ways which might be expected to benefit performance, as a result of including either chlortetracycline or tylosin in the feed.

Table 1. — Ruminal VFA's in Steers Fed Chlortetracycline and Tylosin^a

	Pre-treatment	Control	Antibiotic
Chlortetracycline			
Total concentration (micromoles/ml)	120.5	114.9	106.5
C ₂ :C ₃ ratio	4.1	5.8	4.8
Tylosin			
Total concentration (micromoles/ml)	115.3	99.5	118.9
C ₂ :C ₃ ratio	5.4	4.4	4.4

^a500 mg per steer per day

ABOMASAL NITROGEN IN STEERS FED UREA RATIONS

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

The use of urea as a protein substitute in ruminant rations is dependent on rumen microbial action and the synthesis of nutritious nitrogen compounds. Measurements of the nitrogen constituents that reach the abomasum provide some estimate of the microbial synthesis in the rumen. Past results have indicated that the substitution of urea for soybean meal in finishing rations for beef cattle decreases the total nitrogen and the proportion of protein nitrogen reaching the abomasum. This study was concerned with measuring the nitrogen constituents in the abomasal contents of steers receiving urea with various levels of molasses.

Procedure

Four mature steers with permanent abomasal fistulas were used. Rations of ground ear corn supplemented with urea, urea and 2.5% cane molasses, urea and 10%

cane molasses or soybean meal were fed at 12-hr intervals at a level of 4.0 kg per day. Chromic oxide was added as an indicator. Following 10-day preliminary periods, samples of abomasal fluid were collected once in each 12-hr period for 6 days to provide samples taken at each 2-hr interval after both the morning and evening feedings. A treatment reversal pattern was followed so that each steer received each ration during the experiment, providing four observations per treatment.

The nitrogen components of abomasal fluid were separated into protein and nonprotein fractions, with the latter being further fractionated into amino nitrogen and purine-pyrimidine nitrogen. Quantities of each nitrogen fraction reaching the abomasum were estimated on the basis of nitrogen:chromic oxide ratios relative to intake. The amino acid composition of abomasal contents was determined after complete acid hydrolysis.

Results

The quantities of nitrogen reaching the abomasum in steers on the various treatments are summarized in Table 1. Only 79.4% as much nitrogen reached the abomasum of steers fed urea as in steers fed SBM. Addition of 2.5% molasses to the urea ration increased abomasal nitrogen to 92.5% of that from SBM, and addition of 10% molasses to the urea ration gave no difference relative to the lower level of molasses. The concentrations of abomasal protein and nonprotein nitrogen were similar on all rations; however, steers fed the urea ration showed slightly lower concentrations of purine-pyrimidine nitrogen. There were no significant differences due to ration in molar ratios of amino acids in the abomasum.

Table 1. — Nitrogen Reaching the Abomasum of Steers Fed Urea Rations

	Ration			
	Urea	Urea + 2.5% Mol.	Urea + 10% Mol.	SBM
N intake, gm/day	64.5	69.0	69.6	66.5
N to abomasum, gm/day	60.2	70.1	67.7	75.8
Abomasal N as % of intake	93.3	101.6	97.2	113.9
Relative nitrogen reaching abomasum, % ^a	79.4	92.5	89.2	100

^aSBM set at 100.

ABOMASAL NITROGEN IN WETHERS FED DIFFERENT PROTEIN SOURCES

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

Ruminants are capable of using a wide variety of dietary nitrogen sources through synthesis of microbial proteins by the microorganisms which inhabit the rumen.

The rate of ruminal hydrolysis of dietary proteins and the extent of microbial protein synthesis may affect the efficiency of nitrogen utilization. This experiment was conducted to estimate the changes that take place with dietary proteins in the rumen by measuring the nature and quantity of nitrogen compounds reaching the abomasum of wethers fed protein sources of widely variable chemical and physical properties.

Procedure

Four mature wethers weighing about 120 lb, with permanent abomasal fistulas, were fed four different purified protein sources in a 4 x 4 Latin square design. Purified soybean, zein, casein, and gelatin were the protein sources used in a daily ration of 600 gm ground wheat straw, 300 gm ground shelled corn, 75 gm purified protein source, and 3.0 gm chromic oxide. Following a 7-day preliminary period, samples of abomasal contents were collected twice daily for 6 days at times to represent each 2-hr interval after morning and afternoon feedings. The nitrogen components of abomasal fluid were separated into protein and nonprotein fractions, with the quantity of each fraction reaching the abomasum being estimated on the basis of nitrogen:chromic oxide ratios relative to intake. The amino acid composition of abomasal contents was determined after complete acid hydrolysis.

Results

The percent of intake nitrogen reaching the abomasum was 96.5, 109.4, 88.8, and 85.4 for soybean, zein, casein, and gelatin, respectively. Significantly more of the nitrogen reached the abomasum as protein when zein was fed (74.3%) than when casein (62.5%), gelatin (60.8%), or soybean protein (60.6%) was fed. The amino acid patterns in the abomasal contents were similar with soybean, casein, and gelatin. Wethers fed zein had less threonine, lysine, arginine, aspartic acid, and glycine, and more leucine, phenylalanine, glutamic acid, and proline in abomasal contents. These results indicate qualitative and quantitative differences in nitrogen constituents reaching the abomasum with different dietary protein sources.

EFFECT OF OYSTER SHELL WITH AND WITHOUT ROUGHAGE IN BEEF FINISHING RATIONS

D. B. Williams, N. W. Bradley, C. O. Little, and M. Ward Crowe

Considerable interest in the use of hen size oyster shell as a roughage replacer in beef finishing rations has been shown. The need for a replacer for natural roughage in fattening rations has resulted from the development of the corn picker-sheller where the cob is left in the field, and the problem of harvesting and handling great quantities of silage or other natural roughage by the large feedlots in the West.

Procedure

A 140-day feedlot trial was conducted to study the effect of oyster shell with and without roughage in beef finishing rations. Forty yearling steers averaging 650 lb were allotted to the following treatments, with 2 steers per pen and 5 replications per treatment.

1. Ground ear corn
2. Ground ear corn + oyster shell
3. Ground shelled corn
4. Ground shelled corn + oyster shell

The compositions of the rations used are shown in Table 1. Rations 2 and 4 were formulated so as to provide approximately one-half pound daily intake of oyster shell.

Table 1. — Composition of Rations Used in Feedlot Trial

Ingredients, lb/ton	Ration No.			
	1	2	3	4
Ground ear corn	1788	1746	--	--
Ground shelled corn	--	--	1710	1660
Soybean meal (44%)	193	187	266	259
Oyster shell	--	48	--	59
Ground limestone	9	8	11	10
Salt	10	10	12	12

All rations contained 4 million I.U. of vitamin A per ton.

Results and Discussion

Results of the feedlot trial are shown in Table 2.

Table 2. — Feedlot Performance for 140-Day Trial

Feedlot Data	Rations			
	Ground Ear Corn		All Concentrate	All Concentrate + Oyster Shell
	Ground Ear Corn	+ Oyster Shell		
No. Steers	10	10	10	10
Initial wt, lb	648	649	653	644
Final wt, lb	962.80	937.40	934.40	885.
A.D.G., lb	2.25	2.07	2.01	1.61
Feed Consum., lb	19.03	18.61	16.36	16.12
Feed/Gain	8.63	9.14	8.15	9.26
Cost/cwt gain ^{1/}	\$ 18.30	\$19.19	\$24.41	\$27.31
Transit Shrink, %	4.35	3.55	3.96	3.86

^{1/} Feed costs based on the following prices: ear corn, \$37 per ton; shelled corn, \$55 per ton; oyster shell, \$27 per ton; 44% soybean meal, \$93 per ton; ground limestone, \$30 per ton; salt, \$45 per ton.

The addition of oyster shell to either the 20% roughage ration or the all-concentrate ration tended to depress gain. The 20 steers fed ground ear corn gained significantly

faster ($P < .05$) than steers fed ground shelled corn (2.16 vs. 1.87 lb per day, respectively). The addition of oyster shell also decreased daily feed consumption. Steers fed ground ear corn consumed significantly more ($P < .05$) feed per day (18.81 lb) than steers fed ground shelled corn (16.25 lb).

Occurrence of bloat was observed frequently in the steers receiving oyster shell. Using a visual score of 0 to 4 (none to severe), totals during the last 28 days of the trial for 10 steers on each treatment were: ear corn, 21; ear corn + oyster shell, 193; ground shelled corn, 41; ground shelled corn + oyster shell, 204. Correlation coefficient between bloat score and average daily gain of individual steers was -0.16.

Blood samples taken on the last day of the trial were analyzed for Ca and P to determine if calcium levels or Ca:P ratios were affected by oyster shell in the ration. No significant differences were found. Rumen fluid samples were also collected on the last day of the trial by a suction tube. Rumen pH was significantly higher ($P < .05$) in steers fed ear corn (6.10) than in steers fed ground shelled corn (5.77). No significant differences in total ruminal volatile fatty acid concentration were found; however, the 20 steers fed ground ear corn had a higher acetate:propionate ratio than steers fed ground shelled corn.

At slaughter extensive carcass data were taken. Dressing percent, rib-eye area, marbling score, and carcass grade were not significantly affected by treatment. Damage to ruminal tissue was severe in cattle fed the all-concentrate ration and either ration containing oyster shell. Treatment and number of steers showing a rumenitis condition were: ear corn, 3; ear corn + oyster shell, 7; all-concentrate, 10; shelled corn + oyster shell, 10. Treatment and number of condemned livers were: ear corn, 0; ear corn + oyster shell, 2; all-concentrate, 5; shelled corn + oyster shell, 2.

These data suggest that a natural roughage is necessary in the rations of finishing cattle for optimum performance. Oyster shell in ear corn and all-concentrate rations reduced performance and increased management problems during the trial. Results indicate that oyster shell did not satisfactorily replace "roughage" in high grain finishing rations in this experiment.

UREA AND MOLASSES SUPPLEMENTATION OF GROUND EAR CORN RATIONS FOR FEEDLOT STEERS

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

Previously reported results have indicated that feedlot performance of steers receiving all of their supplemental nitrogen in the form of urea was below the performance of steers fed soybean meal. The addition of molasses to urea-supplemented rations has shown promise of increasing feedlot performance. This experiment was conducted to evaluate the addition of graded levels of molasses to ground ear corn rations supplemented with urea.

Procedure

One hundred twenty yearling steers were fed ground ear corn rations supplemented with soybean meal (SBM), urea, or urea and various levels of molasses for a

124-day feeding period. The steers were assigned to 12 groups of 10 animals each. The complete mixed rations (Table 1) were fed ad libitum.

Table 1. — Composition of Rations Containing SBM, Urea or Urea with Graded Levels of Molasses

	SBM	Urea	Ration ^a			
			Urea + 1.2% Mol.	Urea + 2.5% Mol.	Urea + 5.0% Mol.	Urea + 10% Mol.
			%	%	%	%
Ground ear corn	89.0	89.0	89.0	89.0	89.0	87.1
Ground shelled corn	----	8.1	6.8	5.5	3.1	----
Soybean meal (44%)	9.4	----	----	----	----	----
Urea (281%)	----	1.2	1.3	1.3	1.3	1.4
Cane molasses	----	----	1.2	2.5	5.0	10.0
Ground limestone	0.6	0.5	0.5	0.5	0.4	0.3
Dicalcium phosphate	----	0.2	0.2	0.2	0.2	0.2
Salt	1.0	1.0	1.0	1.0	1.0	1.0

^aAll rations were supplemented with 1000 I. U. vitamin A per lb.

Results

The feedlot performance of the steers is summarized in Table 2. Substitution of urea for SBM as the only supplemental nitrogen source resulted in significant depression in average daily gain and feed intake. The addition of molasses gave only

Table 2. — Feedlot Performance of Steers Fed SBM, Urea or Urea with Graded Levels of Molasses (124 days)

	SBM	Urea	Ration ^a			
			Urea + 1.2% Mol.	Urea + 2.5% Mol.	Urea + 5.0% Mol.	Urea + 10% Mol.
No. Steers	20	20	20	20	20	20
Initial wt, lb	687	689	687	685	689	687
Gain, lb	346	286	308	298	291	308
Av daily gain, lb	2.79	2.31	2.49	2.40	2.35	2.49
Av daily ration intake, lb	25.3	23.1	23.7	24.0	23.8	24.9
Feed/gain	9.05	10.03	9.60	9.93	9.97	10.5

^aAll rations were supplemented with 1000 I. U. vitamin A per lb.

small increases in gains over the urea control, and no difference in level of molasses addition was observed. The reason for this small response from molasses, relative to positive traits in other reports, is not clear. The small increases in performance due to molasses addition to urea rations agree with the increases in total nitrogen reaching the abomasum reported in the preceding article. Steers fed molasses tended to consume more feed than those fed urea alone. While preceding results suggest that ruminal protein synthesis is stimulated by additions of molasses to urea rations, the question as to whether the reported improvement in steer performance is a result of microbial stimulation or improved feed intake is yet to be answered.

LEVEL OF INTAKE AND FEEDLOT PERFORMANCE OF STEERS FED SOYBEAN MEAL OR UREA

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

The preceding report has suggested that decreased feed intake may be a factor affecting feedlot performance of cattle fed urea supplements. This experiment was conducted to compare ground ear corn rations supplemented by urea and soybean meal, at equal levels of intake.

Procedure

Eighteen 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. Six were randomly assigned to three treatments as follows: I - SBM full fed; II - Urea full fed; and III - SBM intake limited to that of the urea ration.

Results

The results of this experiment are summarized in Table 1. Steers on a full feed of the urea ration (II) consumed 1.81 lb less feed per day, gained 0.56 lb less per day, and required 0.95 lb more feed per lb gain than steers full fed the soybean meal supplemented ration (I). Steers receiving the soybean meal supplemented ration at a level of intake equal to that of the urea treatment (III) gained 0.29 lb per day more and required 0.82 lb less feed per lb gain than did the urea-fed steers. These results indicate that feedlot performance of the steers fed soybean meal is superior to performance of steers fed the urea supplement even at the same level of ration intake; however, decreased intake of the urea supplemented ration may partially account for the decreased steer performance.

Table 1. — Feedlot Performance of Yearling Steers Individually Fed Soybean Meal or Urea Supplemented Ear Corn Rations (112 days)

	I SBM (Full Fed)	II Urea (Full Fed)	III SBM (Limit Fed)
No. of steers	6	6	6
Initial wt, lb	692	694	693
Final wt, lb	1019	959	990
Total gain, lb	327	265	297
Av daily gain, lb	2.92	2.36	2.65
Av daily ration intake, lb	21.78	19.93	20.00
Feed/gain	7.49	8.44	7.62

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