REPORT ON

XVIII CONFERENCE ON RUMEN FUNCTION

Americana Congress Hotel, Chicago, IL
November 13-14, 1985

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For the purpose of discussion, the program was divided into four panels. The identity of the panels and the chairman of each follows:

GENERAL CHAIRMAN --- M. J. Allison --- ARS, USDA

(a)	Physiopathology	W. M. Wass
(b)	Agronomy	J. C. Burns
(c)	Microbiology	J. B. Russell
(d)	Nutrition	J. T. Huber

PHYSIOPATHOLOGY

Blood, Urine, and Rumen Fluid Changes Induced by Duodenal Obstruction - T. B. Avery, T. G. Nagaraja, and R. A. Frey, Kansas State University, Manhattan, KS.

Three rumen and duodenal-cannulated cattle were used to study acid-base and electrolyte changes associated with metabolic alkalosis induced by duodenal obstruction. Obstruction was induced distal to the pylorus but proximal to the common bile duct entrance. Rumen fluid, blood, and urine samples were collected before and after obstruction. Duodenal obstruction resulted in severe hypochloremia with a marked increase in blood pH and bicarbonate concentration. Packed cell volume, serum total protein, creatinine, and urea nitrogen increased while potassium and to a lesser degree sodium decreased. Urinary changes followed a biphasic pattern. Renal excretion of sodium and potassium increased initially but declined later. Urine pH increased initially but decreased later. Renal chloride loss reached near zero in 24 hours. Rumen pH decreased and chloride concentration increased indicating reflux of abomasal contents.

Efficacy of Activated Charcoal in the Treatment of Acute Grain Overload - W. B. Buck, University of Illinois, Urbana, IL.

Grain engorgement toxicosis in ruminants probably involves not only a lactic acidosis but, more importantly, an endotoxic shock syndrome. The endotoxemia results from toxins released by the destruction of large numbers of gram negative microorganisms in the rumen. This results in a temporary disappearance of circulatory system white blood cells, rumen atony, circulatory collapse and CNS depression. Activated charcoal appears to be effective in the treatment of grain overload by adsorbing the endotoxins. Field reports by veterinarians to the NAPCC indicate that grain engorged animals in a recumbent position and near a comatose state have recovered within a 24-hour period after being given activated charcoal and bicarbonate.

Rumen Motility and Aflatoxin Metabolism in Acute Bovine Aflatoxicosis - W. O. Cook and J. L. Richard, College of Veterinary Medicine, University of Illinois, Urbana, IL, and National Animal Disease Center, ARS, USDA, Ames, IA.

The effects of aflatoxin on bovine rumen motility were investigated with the aid of radiotelemetry. Aflatoxin altered amplitude and/or frequency of rumen contractions in steers given 0.2 to 0.8 mg of aflatoxin/kg BW. Alterations in rumen motility were detected 24 hours after aflatoxin administration. Evidence of normal rumen motility was present within 2 to 3 days after alterations appeared. Decreased elimination of aflatoxin from rumens was observed in steers given 0.4 to 0.8 mg of aflatoxin/kg BW. Effects of aflatoxin on rumen motility appeared to be dose dependent. Changes in rumen motility coincided in time with clinical observations of anorexia and severity of liver damage detected by clinical pathology. Aflatoxin M_1 was detected in relatively high concentrations in rumen contents 2 hours after aflatoxin administration. This suggested intraruminal metabolism of aflatoxin B_1 to M_1.

Structure of the Reactive Intermediate of 3-Methylindole Responsible for Acute Lung Injury - J. R. Carlson, M. R. Nocerini, G. S. Yost, D. J. Liberato, Dept. of Animal Sciences and College of Pharmacy, Washington State University, Pullman, WA, and NIH-NICHD.

3-Methylindole (3MI) is a ruminal fermentation product of tryptophan that causes acute lung injury in ruminants, horses, and some other animals. The effects of 3MI are organ, cell and species specific. The lung is the target organ and injury results from cytotoxic effects to the Type I alveolar epithelial cells and nonciliated bronchiolar epithelial (Clara) cells in ruminants while only Clara cells are damaged in horses. Cytotoxic effects are mediated through mixed function oxidase metabolism of 3MI which causes the formation of a highly reactive intermediate that covalently binds to cellular macromolecules. The amount of covalent binding of the reactive intermediate is proportional to dose and the severity of lung injury. This reactive intermediate can be detoxified by conjugation with gluthathione to form a 3MI-GSH adduct which has been isolated using HPLC techniques. Conjugation of 3MI with gluthathione is inversely proportional to covalent binding and the severity of lung injury.

Studies were undertaken to identify the structure of the reactive intermediate using thermospray liquid chromatography/mass spectrometry along with UV and NMR spectrometry. Goat lung microsomes were incubated for 1 hour with ^{14}C-3MI, glutathione, and a NADPH generating system. The adduct was isolated from the incubation supernatant by reverse phase HPLC. The adduct was identified by UV absorbance and radioprofiles as previously reported. UV spectral analysis indicated an absorption maximum at 216 and 280 nm suggesting that the indole ring was intact. Using mass spectroscopy, a molecular ion of m/z 437 was obtained corresponding to the molecular weight of a GSH-3MI adduct. Fragments of the adduct appear at 147 and 130 corresponding to cleavage of amino acid fragments from the tripeptide. NMR results demonstrated that conjugation occurs at the methyl group of 3MI and the 3MI-GSH adduct was shown to be 3-(glutathion-S-yl)-methyl indole. The most likely structure of the reactive intermediate of 3MI responsible for acute lung injury is the imine methide of 3MI. These findings are consistent with formation of known end products of 3MI metabolism.

Feed Aversion Induced in Cattle by Rumen Infusion of Larkspur Extract or Lithium Chloride

J. D. Olsen and M. H. Ralphs, USDA, Agricultural Research Service, Poisonous Plant Research Laboratory, Logan, UT

Cattle poisoning by larkspur on rangelands could be greatly reduced if persistent aversion to the plant could be induced.

In a preliminary experiment, we induced a strong feed aversion to alfalfa pellets by pairing feeding of the pellets with infusion of larkspur extract or lithium chloride solution into the rumen of cattle.

Twelve Hereford heifers were surgically prepared for infusion via a rumen catheter and were randomly assigned to 3 conditioning treatments (I Larkspur extract; II Lithium chloride solution; III Saline control). All heifers were given a basal ration of meadow grass hay throughout the persistence phase of the experiment. After 3 weeks of basal ration all heifers were offered a novel ration of alfalfa pellets in a 2-Phase, one-day feeding regimen. In Phase 1, amount eaten within 45 minutes was measured by weigh-back of uneaten pellets. In Phase 2 all heifers having eaten > 150 g of pellets were offered the balance of uneaten pellets and given infusions of one of the solutions listed above. Five single-day feedings of pellets were given at 2- or 3-day intervals to induce feed aversion. All animals in Groups I and II developed aversion to pellets by the 5th single-day feeding.

Persistence of aversion was tested by measuring alfalfa pellets eaten during a 45-minute period (Phase I only) at intervals up to 35 weeks. The mean intake of pellets by the larkspur group (356 g ± 398) and lithium group (415 ± 651) was still significantly less than the control group (2360 ± 1258) at 35 weeks after the aversion was induced. Two animals in each of the larkspur and lithium groups began to show some extinction of the aversion by 12 weeks after the induction period. One control animal had a marked variation in consumption of alfalfa pellets which reached a low of 530 g at 35 weeks.

This study confirmed that cattle have a neurophysiologic mechanism for forming a strong feed aversion. Intraruminal infusion of larkspur extract or lithium chloride induced a strong aversion which persisted for at least 35 weeks. Extinction of the aversion began in some animals by 12 weeks after the induction period.

Do Soluble Constituents in Silage Affect Oro-Pharyngeal Responses in Sheep?
J. G. BUCHANAN-SMITH, Dept. of Animal and Poultry Sci., University of Guelph, Guelph, ONT., N1G 2W1

It is appreciated that potential forage intake is reduced through the ensiling process. Taste and smell of silage constituents may be partially responsible. Given a choice, ruminants generally prefer to eat silage with lower rather than higher levels of constituents. However, ruminants fed silage, in common production systems, don't have a choice. The objective of this research was to determine if silage constituents can induce feed rejection when no choice is given. Four or five mature wethers fitted with esophageal cannulae (1) were used. Each experiment consisted of offering the wethers, starved for 5 h, silage (50-60% DM) and water and/or silage extracts (1:1.5, w/w) and measuring sham intake over a 30 min. period. The water contained pure silage constituents or was mixed with extracts in differing proportions. Eight studies testing different constituents or levels of extracts, in 4x4 or 5x5 latin square designs, were conducted. Each study was preceded by adaptation of sheep to each constituent or extract over 10d. The following summarizes results of these studies:

Study No.	Item and Maximum Level Tested	Result
1	Silage extract, good quality, to full amount	No effect ($P>0.1$)
2	Silage extract, poor quality, to full amount	No effect ($P>0.1$)
3	Lactic and acetic acids to 5.3 and 3.6g/100 g silage DM, respectively	No effect ($P>0.1$)
4	Acetic acid to 8.8g/100g silage DM	Linear inhibition of intake ($P<0.05$)
5	Butyric and acetic acids to 5.4 and 3.6g/100 g silage DM, respectively	No effect ($P>0.1$)
6	Ammonia to 0.39g NH_4-N/100g silage DM	No effect ($P>0.1$)
7	Free amino acids to 1.38g NH_2-N/100 g silage DM	Quadratic inhibition of intake ($P<0.1$)
8	GABA, putrescine and cadaverine to 1.11, 0.67 and 0.67g NH_2-N/100g silage DM, respectively	Quadratic enhancement of intake ($P<0.05$)

It was concluded that ensiling should not inhibit intake by oro-pharyngeal mechanisms apart from any instance where a silage contains extremely elevated levels of acetic acid, without lactic acid being elevated also, or extremely elevated levels of free amino acids.

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1. Chapman, H. W. and Grovum, W. L. 1984. Esophageal fistulation of sheep for sham feeding studies. Can. J. Anim. Sci. 64(Suppl.):106-107.

AGRONOMY

Animal and Plant Productivity as Affected by Globally Synchronous Annual Changes in Available Soil Minerals - C. H. Mullenax, Univ. Coop. Extension Prog., University of Missouri, Columbia, MO.

Current research and an on-going retrospective review of world literature (n = 220) provide strong evidence that, independent of the traditional climatic variables except at their extremes, there occur synchronously around the globe marked decreases in soil, plant, and animal productivity parameters each year during the period May to August. These include: (1) Decreases, modified by soil type and depth, in available (extractable) soil nutrients followed in September-November by an "efflux" of these nutrients; (2) Decreases in dry matter production and in foliar and root nutrient content of physiologically young (e.g. continuously grazed) forages; (3) Decreases in grain produced by cereals planted in June vs. May in the Northern Hemisphere, or May/June vs. October/November where the climate permits successive plantings; and (4) Decreased productivity and health status of pastured livestock. Secondary decreases of lesser magnitude may be seen during December/January in geographic areas climatically suitable for plant growth at this time.

In both the Southern and Northern Hemispheres, whether causally or coincidentally, these decreases occur synchronously with the down phases of the equatorial electrojet, the seasonal variations in the Sq current system, and the global atmospheric electric circuit.

Other agricultural consequences of these phenomena include marked proliferation of fungi associated with the debilitated plants, the mycotoxins of some of which exacerbate pre-existing nutritional deficiency/imbalance syndromes in grazing animals. This is exemplified by a beriberi-like, thiamin-responsive syndrome in cattle pastured on wet tropical savannas in South America.

Soil and forage analyses guide the application of means for modifying the effects of the down phase, some of which are: (1) Precise formulation (including of the fungistatic elements) and application of complete fertilizers; (2) Exploitation of newly planted and/or shallow-rooted species of plants (e.g. in pasture "renovation"); (3) Early planting of crops in the Northern Hemisphere; and (4) Use of growth (production) promoting agents in grazing livestock. Some which have been found to be effective under various conditions include flavofosfolipol, thiamin, monensin, and zeralanone.

Other biorhythms functioning on similar cycles in animals and their parasites are mentioned as points of potential confusion to be avoided in data interpretation.

Ionophore Effects in Spring-Calving Beef Cows Grazing Tetany-Prone Tall Fescue. J. A. BOLING, N. GAY, G. M. DAVENPORT, L. D. BUNTING, K. A. DAWSON and K. M. MEEKINS, Department of Animal Sciences, University of Kentucky, Lexington, KY 40546.

Thirty-two spring-calving beef cows of Hereford, Angus and Hereford x Angus breeding were used to study the influence of lasalocid on selected blood and rumen constituents when grazing tetany-prone tall fescue pasture. The cows averaged 6.2 years of age and were allotted to four groups by age and breed. Each group was randomly assigned to one of four tall fescue pastures of 5.66 ha each. Cows in the control treatment were fed 0.91 kg of supplement per head daily which contained 56 g steamed bone meal, 42 g trace mineral salt, 30,000 I.U. vitamin A and the remainder ground shelled corn. The lasalocid treatment was fed 300 mg lasalocid per head daily in a supplement of similar composition. Both supplements analyzed 0.13% magnesium. The study was initiated March 6 and terminated May 1. Blood samples were taken by jugular puncture and placed in heparinized tubes on days 7, 14, 28, 42 and 56 of the trial. Forage samples were taken from four sites within each pasture on these same dates. Rumen fluid samples were taken by stomach tube on day 42.

Forage composition was similar in pastures grazed by the control and lasalocid-fed cows. Tall fescue forage throughout the trial (5 sampling times and 16 samples per time) averaged 0.19% magnesium, 21.2% crude protein, 3.1% potassium, 0.77% sodium, 0.62% calcium and 0.33% phosphorus on a dry matter basis. Rumen fluid constituents measured on day 42 for control and lasalocid cows, respectively, were: Mg-4.28, 4.24 mg/dl; K-24.8, 22.7 meq/l; Na-133, 136 meq/l; NH_3-N-7.98, 8.96 mg/dl. Plasma constituents measured across all sampling times for control and lasalocid cows, respectively, were: Mg-2.05, 1.87 mg/dl; Ca-9.48, 9.36 mg/dl; P-5.07, 5.49 mg/dl; urea-N-20.3, 19.4 mg/dl; K-6.20, 6.09 meq/l; Na-181, 182 meq/l. Two cows in the control group developed hypomagnesemic tetany (collapse). The dates of tetany were April 3 and April 11. Even though plasma magnesium concentrations were slightly lower in lasalocid-fed cows than in controls, none of the cows fed lasalocid developed hypomagnesemic tetany.

Use of Tethered Steers for Estimating Intake of Fescue Pasture.

R. A. HITCHCOCK[1], R. B. MUNTIFERING[1], N. W. BRADLEY[1], A. WAHAB[2], P. J. BALLERSTEDT[2], C. T. DOUGHERTY[2], R. B. RAZOR[3] and E. M. SMITH[3], Departments of Animal Sciences[1], Agronomy[2] and Agricultural Engineering[3], University of Kentucky, Lexington, KY 40546-0215.

We have developed a simple experimental grazing system using tethered steers which eliminates or greatly minimizes error due to variables other than the forage(s) under study, possesses desirable and efficient experimental design characteristics, and provides reliable quantitative information regarding the animal-forage interface. In the first of a series of experiments conducted during the summers of 1984 and 1985, six half-sib yearling Angus steers (init. wt., 281 kg) were assigned to graze on two Kentucky-31 tall fescue pastures (three steers/pasture) for 5 wk. Pastures were clipped in sections to establish a system in which grazing could be continued for 1 wk at an approximately uniform stage of vegetative regrowth. Each wk thus represented a specific regrowth (7, 14, 21, 28 and 35 d) stage. Grazing time was limited to two periods/d beginning at at 0800 and 1400 h. On the average, satiety was achieved after 2 h of continual grazing in each period. Forage availability was controlled by adjusting tether length, which was set at approximately twice the estimated daily dry matter (DM) intake. Fecal DM output was measured by Cr_2O_3 concentration in grab sample composites. Across all regrowth periods, forage DM digestibility estimated by reference to lignin ratio (63.4%) and IVDMD (59.7%) differed ($P<.05$). Daily DM intake (kg, g/$BW^{.75}$ and % of BW) across all regrowth periods differed ($P<.05$) between lignin ratio and IVDMD methods (9.1, 125.9 and 3.0 vs 7.7, 107.4 and 2.6, respectively). Coefficients of variability associated with estimates of digestibility and intake were lower for IVDMD than lignin ratio. Overall daily liveweight gain for the trial averaged 1.1 kg. Use of tethered steers represents a labor-efficient and cost-effective method for determining the intake potential of forage. Its application has since been extended to include intensive study of intake components (biting rate, bite size) as a function of physical/chemical aspects of forage, forage species and availability, and level of energy supplementation.

Digestion of Normal and Brown Midrib Sorghum. D. E. Akin, L. L. Rigsby, M. E. Snook, D. S. Himmelsbach, F. E. Barton, II, and W. R. Windham, ARS, USDA, Russell Research Center, Athens, GA; and W. W. Hanna, ARS, USDA, Coastal Plain Experiment Station, Tifton, GA.

Reduced lignin contents of the brown midrib (bmr) mutation in Sorghum bicolor L. Moench results in improved cell wall digestibilities compared with normal plants. A collaborative effort was undertaken to elucidate biological and chemical characteristics altered by the bmr mutation in line 12 (Porter et al., 1978, Crop Sci. 18:205). No differences occurred in the lignin histology or in the proportion of tissues in leaves between plants types. Scanning electron microscopy showed that the adaxial sclerenchyma and the parenchyma bundle sheaths in the non midrib portion of leaf blades was more readily degraded by rumen microorganisms in bmr compared with normal plants. In the midrib portion, the parenchyma cells were more readily degraded in bmr leaf blades. In vitro dry matter digestibilities showed that the midrib digestibility was 55% and 77% for normal and bmr plants, respectively, and the non midrib portion was 73% and 76%. The more rigid and lignified tissues (e. g., xylem) were not degraded in either plant type. Leaf blades of bmr plants were lower ($P \leq .05$) in neutral detergent fiber and permanganate lignin (PML) and leaf sheaths were significantly lower in PML. Solid-state nuclear magnetic resonance (NMR) spectroscopy suggested that bmr had lower amounts of bound syringyl moieties, which may relate to the improved digestibility of midrib parenchyma in bmr leaves. Six phenolic acids were identified in extracts (1 N NaOH) from each plant type, and the predominant acids were p-coumaric and ferulic. p-Coumaric acid, which is the most toxic acid in in vitro systems, was significantly lower in bmr leaves. Data suggest that reduced levels of phenolic acids, especially p-coumaric acid, and reduced levels of etherated syringyl moieties in conjunction with reduced lignin levels result in improved degradation of marginally digested tissues in bmr plants, but the highly lignified tissue types are not degraded in either plant type.

Dry matter intake by steers and apparent digestion coefficients for dry matter and cell wall constituents of subtropical grasses with similar NDF concentrations. J. C. Burns, R. D. Mochrie and D. H. Timothy, USDA, ARS and Departments of Crop Science and Animal Science, North Carolina State University, Raleigh, NC 27695.

Coastal bermudagrass [Cynodon dactylon (L.) Pers.] has served as an important forage in the southern USA. However, its use as a growing or conditioning forage for yearlings has not been satisfactory. Generally, steer daily gains have averaged less than 0.5 kg. Other subtropical perennials as flaccidgrass (Pennisetum flaccidum Griseb.) and switchgrass (Panicum virgatum L.) have given steer daily gains of about 1.0 kg. The objective of this study was to compare dry matter intake and apparent digestion coefficients for dry matter and cell walls and constituent cell wall fractions of Coastal bermudagrass (CB) with those of flaccidgrass (FG) and switchgrass (SG) when cell wall concentrations were similar. Tall fescue (Festuca arundinacea Schreb.) was included for comparison to a temperate forage. The hays, fed to Holstein heifers in two 4 x 4 Latin squares, had NDF concentrations for CB, SG, FG and tall fescue (TF) of 74.2, 75.3, 71.0 and 62.1 %, respectively. Dry matter intake (kg/100 kg body weight) averaged (n = 8) highest ($P \leq 0.05$) for CB (2.70), lowest for SG (2.09) and similar to TF (2.25) with TF and FG intermediate and similar (2.29). In vivo digestion coefficients obtained following only the fourth period of the intake phase averaged (n = 2) lowest for CB (0.435) and similar for the others (0.587). Respective values for acid detergent fiber, hemicellulose and cellulose of CB were 0.435, 0.537 and 0.517. These were each lower than obtained for the other three forages which had similar values averaging 0.587, 0.722 and 0.675, respectively. The higher dry matter intake for CB but lower digestion coefficients for dry matter and fiber fractions (at similar NDF concentrations) suggests that CB is apparently reduced more in the mastication and rumination process than are the other forages, but the resulting particles are less well utilized by rumen organisms.

Inhibition of cellulose digestion by esterified cinnamic acids. H. G. JUNG and T. SAHLU, USDA, ARS, Clay Center, NE 68933

Cinnamic acids commonly found in forages were esterified to cellulose and tested for their inhibition of cellulose degradation by mixed cultures of rumen microorganisms *in vitro*. Concentrations of cinnamic acids used in the cellulose esterification procedure were 20-100 $g \cdot kg^{-1}$, but measurement of actual ester concentrations by alkaline extraction were not possible for solka floc cellulose and ranged from 0 to 9.5 $g \cdot kg^{-1}$ for Whatman No. 54 filter paper cellulose. Cinnamic acid esters significantly depressed cellulose digestion. For both cellulose sources, caffeic acid was the most inhibitory compound. Solka floc cellulose digestion was also inhibited by sinapic acid, whereas p-coumaric and ferulic acids also depressed digestion of filter paper cellulose. The fact that the linear model of cellulose digestion as a function of original treatment concentration gave a better fit to the data than the model of digestibility as a function of measured alkali-labile ester concentration implies that alkali extraction does not accurately quantify cinnamic acids in forages. The proportions of volatile fatty acids produced by fermentation of filter paper were not altered by cinnamic acid esters. Esterified cinnamic acids depressed cellulose digestion to a significantly greater extent than did free cinnamic acids. The data suggest that the natural form of cinnamic acids (ester-linked to cell wall fiber) are inhibitors of microbial digestion at concentrations reported to occur in forages.

MICROBIOLOGY

Comparison of Rumen-Fistula with Stomach-Tube Collected Ruminal Fluid Inocula in Batch Culture Fermentation - M. L. Ogilvie, J. A. Z. Leedle, R. C. Greening and D. D. Kratzer, The Upjohn Company, Kalamazoo, MI.

A study was conducted to compare the in vitro fermentation characteristics from inocula taken by stomach tube via the esophagus or through the rumen cannula of fistulated heifers fed a 70% concentrate-30% corn silage diet. Ruminal contents, obtained from each of six animals on two separate days, were squeezed through two layers of cheesecloth, diluted 10 fold with buffer and incubated in batch culture with .5 g ground feed. Characteristics measured after 0, 6, 12 and 24 hours of fermentation were: pH, dry matter, ammonia-N, lactic acid and volatile fatty acids (VFAs). Total gas and methane production were monitored hourly.

The proportions and concentrations of individual VFAs together with the patterns of total gas and methane production demonstrated that typical in vitro fermentations were established and maintained over the 24 hour incubation period. Accumulation of the fermentation products was accompanied by a corresponding utilization of substrate dry matter and a decline in pH. Mean values of all the fermentation characteristics were not significantly different ($P < .05$) for inocula from the two sources. Total gas and methane production data showed exponential and sigmoidal appearance curves having nearly identical nonlinear regression equations for either stomach tube or fistula ruminal fluid sources. A significant effect due to day of sampling was limited to concentrations of some but not all VFAs and was not evident for pH, dry matter, ammonia-N, lactic acid and total gas or methane production. These results indicated that strained ruminal fluid taken from the same animal either by aspiration through a stomach tube or through the cannula of a rumen fistula responded the same when incubated in a typical batch culture system. Based upon these measurements, the samples of ruminal contents taken by either of the two sampling procedures were assumed to yield similar microbial populations.

EVALUATION OF AN *IN VITRO* SYSTEM USING A WASHED BACTERIAL INOCULUM

Evaluation of an in vitro system using a washed bacterial inoculum. J. Argyle, Dept. of Animal Sci, University of California at Davis, Davis, CA, and R. B. Hespell, Northern Regional Research Center, ARS, USDA, Peoria, IL.

We wanted to demonstrate that an *in vitro* fermentation system in which ruminal fluid was replaced by a washed bacterial suspension as inoculum and a buffer containing most of the rumen microbial growth factors could produce a rumen like fermentation. This system would be free from the variability and interference seen when using ruminal fluid as a source of growth factors. The number of cellulolytic organisms present in the washed cell suspension was shown to be lower than the number present in ruminal fluid, but the difference was statistically not significant. Methane production in cultures inoculated with a washed cell suspension was lower than that from ruminal fluid inoculated cultures, but the kinetics changed in both cultures at the same time, indicating that the difference was due to fermentation of substances in the ruminal fluid. The methanogenic population in cultures inoculated with the washed cell suspension was shown to remain viable for three days, and then rapidly declined. Examination of suspension inoculated cultures for abnormal fermentation products revealed that ethanol and succinate were not produced. A small lactate peak was seen only at 2 hours. Traces of hydrogen were produced during the first few hours, but were never significant. The VFA were produced in the expected ratios. Ammonia was not produced from alfalfa until after 18 hours, but was shown to be taken up during the first 12 hours when supplied exogenously. In spite of a need for ammonia, the presence of a source of ammonia in the buffer did not have any effect on CH_4 or VFA production, but did increase the number of bacteria after 12 hours. Digestion of dry matter and NDF could be shown within 2 hours of inoculation. We concluded that a washed bacterial suspension can be used in place of ruminal fluid if more defined *in vitro* conditions are desired.

Adaptation of a Semicontinuous System to Test the Effects of Chemicals on Rumen Fermentation - P. F. Machado, R. M. Cook, and P. Kone, Dept. of Animal Science, Michigan State University, East Lansing, MI 48824.

A semicontinuous technique was adapted to investigate the influence of monensin (M) and isoacids (I) on rumen fermentation. The system consisted of a 250 ml erlenmeyer fitted with a manometer for total gas measurement and ports for culture transfer. The procedure was based on daily replacement of 50 ml of the old culture by the same amount of the new media for a period of 10 days. The culture was established using inoculum from a cow fed tymothy hay. The media contained wheat straw, urea and ammonium sulfate (1.0 g, 0.1 g and 0.05 g/100 ml, respectively), minerals and vitamins. On the fourth day, M (400 µg/100 ml), I (equal proportions of isobutyric, 2-M-butyric, isovaleric and valeric acids) (4 mg/100 ml), M plus I [(M+I)/2] (200 µg and 2 mg/100 ml, respectively) and M plus I (M+I) (400 µg and 4 mg/100 ml, respectively), were added to a series of three flasks per treatment. From the fifth to the tenth day, only half dose of the chemicals were added. Establishment of rumen-like fermentation was confirmed by low H_2 concentrations and normal proportions of acetate, propionate and butyrate throughout the trial. Acetate production was increased in M+I in relation to M flasks (3.77 vs. 2.30 meq/100 ml) ($P < 0.10$). Methane production in relation to the control (14.05%), decreased in M and (M+I)/2 flasks, but increased in M+I (5.94%, 9.48% and 17.85%, respectively) ($P < 0.05$). Total gas production, H_2 and NH_3-N levels were not influenced by chemicals.

The combination of monensin and isoacids may have resulted in outgrowth of Bacteroides succinogenes, leading to a higher degradation of cellulose in M+I in relation to M flasks. The combination, however, did not eliminate the effect of monensin in increasing propionate production.

Rumen Microbial Development in Early or Conventionally-weaned Calves - K. L. Anderson, T. G. Nagaraja, J. L. Morrill, and T. B. Avery, Department of Animal Sciences, Kansas State University, Manhattan, KS.

Eight bull calves were rumen fistulated at 3 days of age, and allocated to one of two weaning programs. All calves were fed colostrum for 3 days after birth and milk until weaning. Calves in the conventional weaning program were fed a starter diet and weaned at 6 weeks of age. In the early-weaning program, calves were fed a highly palatable prestarter diet composed of milk solids, supplementary fat and additives until they consumed 250 g per day and then fed the starter diet ad libitum. Calves in this group were weaned at 4 weeks of age. Rumen samples were collected at weekly intervals for up to 12 weeks of age and analyzed for microbial types and fermentation products.

Calves in both groups had similar patterns of rumen microbial development. Total volatile fatty acid concentrations increased progressively in both groups. Calves in the early-weaned group, however, had higher concentration of total rumen volatile fatty acids at an earlier age than the calves in the conventional weaning program. This was accompanied by a trend toward higher concentrations of lactate and lower rumen pH in this group during their first four weeks of age. Lactate and ammonia concentrations decreased with calf growth. Amylolytic, proteolytic, lactobacilli, lactate utilizers, cellulolytic, and methanogenic bacterial populations increased progressively in both groups. Cellulolytic and methanogenic organisms were present in both groups at 3 days of age. The total anaerobic bacterial counts increased only slightly as the calves developed, while Streptococcus sp. and facultative bacterial populations decreased with calf growth. No protozoa was detected in calves of either group. In general, the most significant changes in microbial populations and metabolic products in both groups occurred between 3 and 4 weeks of age.

Recent Advances in Bacteroides Genetics - A. A. Salyers and N. B. Shoemaker, Dept. of Microbiology, University of Illinois, Urbana, IL.

Shuttle vectors which replicate in both E. coli and Bacteroides and which can be mobilized from E. coli to Bacteroides are now available (pE5-2, pDP1). Since antibiotic resistances and replication origins of E. coli generally do not work in Bacteroides and vice versa, these shuttle vectors contain resistance genes and replication origins for both E. coli and Bacteroides. Mobilization from E. coli to Bacteroides occurs at highest frequencies (10^{-3} to 10^{-4}) if matings are done aerobically. Frequencies are lower for anaerobic matings (10^{-5} to 10^{-6}). Recently, transfer of shuttle vectors among Bacteroides has been achieved. In this case, anaerobic matings give the highest frequencies. A Bacteroides transposon, Tn4351, has been discovered and can be introduced into Bacteroides on a broad host range E. coli plasmid, R751. Tn4351 inserts itself and can also mediate cointegration of R751 in the Bacteroides chromosomes. R751 transfer functions appear not to work in Bacteroides. Tn4351 insertions produce auxotrophs. Thus, Tn4351 may prove useful for mutagenesis of Bacteroides. Mutations in specific Bacteroides genes have also been made by recombinational insertion into the Bacteroides chromosome of a segment of a gene that was cloned into a suicide vector.

Phenolic Compounds and Rumen Bacteria - Scott Borneman and D. E. Akin, ARS-USDA, Russell Research Center, Athens, GA.

Phenolic compounds have been suggested as a limitation to forage digestibility by binding with carbohydrates or exhibiting toxicity to rumen microorganisms. Phenolic acids as well as partially metabolized phenolic acids provide a diverse group of phenolic compounds in the environment of the rumen population. Work presented here gives the disposition of rumen microorganisms to a series of phenolic compounds and concentrations in order to acquire fundamental information on the potential limits to forage utilization. Ruminococcus albus 7, R. flavefaciens FD-1, Butyrivibrio fibrisolvens 49, and Lachnospira multiparus D-32 were tested against 1, 5, and 10 mM concentrations of ten phenolic compounds. Influence on growth was evaluated by comparing growth rate and maximum absorbance of cultures grown in complete media with or without the phenolic compounds. Responses were mixed and depended upon the phenolic compound and the microbial species. Compounds especially toxic (i.e., poor growth, effect on several species, dose response) were p-coumaric acid and p-hydroxybenzaldehyde. Syringic, p-hydroxybenzoic, and hydrocinnamic acids stimulated growth of most of the microbes tested, and the former two compounds stimulated filter paper degradation by R. flavefaciens. None of the stimulatory compounds supported microbial growth in the absence of carbohydrates. Solka Floc digestion by rumen fluid was not stimulated by the phenolic compounds (10 mM), but the phenyl propanoid acids and phenylaldehydes (10 mM) reduced ($P<.05$) digestion by the mixed populations in rumen fluid. Our results showed that responses for these pure cultures were not always indicative of that for the whole population, but phenylpropanoid acids and phenylaldehydes were especially toxic to microbes degrading Solka Floc.

Effect of 3-Phenylpropanoic Acid on the Growth and Cellulolytic Activity of Selected Ruminal Bacteria - R. J. Stack and M. A. Cotta, USDA-ARS, Northern Regional Research Center, 1815 N. University Street, Peoria, IL.

Ruminococcus albus strain 8 requires 3-phenylpropanoic acid (PPA), a normal constituent of rumen fluid, for optimum rates of growth in a defined medium with cellulose as the carbon and energy source. Cells grown in the presence of PPA produce large extracellular muralytic (cell wall-degraded) enzyme complexes apparently derived from the release or sloughing off of capsular material. These complexes contain 8-12 polypeptide components and an amino acid/carbohydrate-containing material with covalently-linked PPA.

Recent difficulties encountered by several workers trying to grow cellulolytic ruminal bacteria on various defined media prompted us to examine the effect of PPA on cellulose utilization by some of these organisms. PPA had no effect on rates of cellulose utilization for Ruminococcus flavefaciens strains FD1 or C94 or Butyrivibrio fibrisolvens strains 12, 49, or A38. With Ruminococcus albus strain 7, however, PPA greatly enhanced rates of cellulose utilization while having little effect on growth rates if cellobiose were substituted for cellulose in the medium. We suggest that PPA-stimulation of cellulose utilization might be a useful taxonomic tool for distinguishing between R. albus and R. flavefaciens.

Some New Rumen Bacteria Capable of Phenolic Conversions. Lee R. Krumholz and M.P. Bryant. Dept. of Animal Science, Univ. of Illinois, Urbana, Illinois 61801.

Phenolic compounds are ubiquitous in plants and are found at levels of up to several percent of the dry weight in forages fed to ruminants. A number of biological effects of phenolics have recently been proposed, which include suppressed growth of rats and chicks, and inhibition of the growth and cellulolytic activity of rumen bacteria.

In order to understand the effects of phenolics within the rumen and on the ruminant, the possible conversions of phenolic compounds have been studied and bacteria capable of carrying out these processes isolated. Bacteria capable of modifying gallate (3,4,5-trihydroxybenzoate) within the rumen were enumerated by log fold dilution to extinction (MPN). The phenolic products were identified and quantitated at each dilution. Those capable of decarboxylating gallate to pyrogallol were present in rumen fluid at 9.3×10^6 cells per ml. Those carrying out the reductive dehydroxylation reaction converting pyrogallol to resorcinol were present at 9.3×10^5 cells per ml and those converting gallate to non aromatic products at about 4.3×10^3 cells per ml.

Strain G41 was isolated from the highest dilution of rumen fluid that exhibited growth on pyrogallol (1,2,3-trihydroxybenzene,10^{-3}). Strain G41 catabolized pyrogallol, gallate, phloroglucinol (1,3,5-trihydroxybenzene) or quercetin with a requirement for equimolar quantities of formate or hydrogen with the phenolic. Growth was also obtained on crotonate but none of the other substrates tested allowed growth. Products were acetate and butyrate in all cases and with quercetin, dihydroxyphenylacetate. Strain G41 is a Gram positive, curved rod shaped organism. It is strictly anaerobic and does not produce spores. It therefore fits in the genus Eubacterium and the new species was assigned oxidoreducens.

Organisms capable of growing by demethoxylating phenolic compounds were enumerated by MPN estimation. Bacteria capable of growing on syringate (3,5-methoxy-4-hydroxybenzoate) or ferulate (3-methoxy-4-hydroxycinnamate) are present at 10^6 to 10^7 cells per ml. Strain S195 was isolated from the highest dilution of rumen fluid showing growth on syringate. It is a Gram negative coccus that grows on sugars while cometabolizing the methoxyl group. The hydroxylated phenolic as well as acetate and carbon dioxide are products. Very little growth is obtained on either methoxyl groups or sugars alone. Either the double bond of cinnamate derivatives, formate or a hydrogen utilizer such as Methanobrevibacter will substitute for the methoxyl groups.

These results indicate that strain S195 uses sugars to produce acetate, CO_2 and electrons. The electrons can then be used to reduce formate or methoxyl groups to acetate, or protons to hydrogen if a hydrogen utilizer is present. Based on its unique physiology, Stain S195 was named Syntrophococcus sucromutans as it did not adhere to any of the previously defined genera.

Effect of Pentachlorophenol (PCP) Selectivity on Rumen Bacterial Species - M. T. Yokoyama and K. A. Johnson, Dept. of Animal Science, Michigan State University, East Lansing, MI.

Pentachlorophenol (PCP) is one of the most widely used industrial and agricultural biocide in the world. Most of the PCP produced is used in wood preservation, but it is also used as a herbicide, insecticide, algicide, fungicide and bactericcide. Livestock are exposed to PCP by the use of PCP treated wood for buildings, fences and feed bunks or by the use of contaminated wood shavings or sawdust as bedding. Although the exact mechanism of action of this compound is still unclear, it is a potent uncoupler of oxidative phosphorylation and a protonophore. Previous research has shown that technical grade PCP (t-PCP) will alter the ruminal fermentation and depress cellulose digestion (Shull and McCarthy, 1977). The objectives of this study were: (1) to determine the effect of analytical grade (a-PCP) on the mixed rumen bacterial population, and (2) To determine the sensitivity of predominant rumen bacterial species to a-PCP. When examined in vitro at increasing concentrations (5-100 µg/ml), a-PCP markedly decreased propionate, acetate and total VFA production and increased butyrate production. Mixed rumen bacterial growth was also decreased. Growth of B. succinogenes S85 was depressed at 2.5 and 5.0 µg/ml PCP, and completely inhibited at higher concentrations. R. albus 7 was completely inhibited at 5.0 µg/ml. B. amylophilus H18 was inhibited by 50% with 2.5-20 µg/ml PCP, but S. bovis 24 was completely resistant to these concentrations. Of the saccharolytic species, B. ruminicola GA33, M. elsdenii B159 and B. fibrisolvens D1 were resistant to all concentrations of PCP. S. dextrinosolvens 22B, S. ruminantium HD4, Treponema bryantii B,5 and B. fibrisolvens A38 were sensitive to PCP, but showed a higher tolerance and adaptability to increasing concentrations. The data indicates that cellulolytic species are more sensitive to PCP than either amylolytic or saccharolytic species, and the sensitivity of rumen bacterial species to PCP is dependent on the contribution for growth of substrate level and electron transport processes used by the individual species.

Microbial Ecology of Protolysis in the Rumen - R. J. Wallace, The Rowett Research Institute, Aberdeen AB2 9SB, Scotland.

Rumen bacteria with the highest activity for proteolysis in vitro are not necessarily the most important in vivo. Highly active isolates of Butyrivibrio, Fusobacterium and Bacteroides amylophilus have enzymes mainly of the serine protease type, different to the cysteine proteases mainly found in rumen liquor. Furthermore, the most active butyrivibrios produce an exocellular enzyme, unlike the mainly cell-bound activity of rumen fluid. Bacteroides ruminicola, Eubacterium spp., low-activity Butyrivibrio spp. and Selenomonas spp. are probably of greater importance, with Streptococcus bovis notable for its very high leucine aminopeptidase activity. Synergism between different species occurs, which makes assessment based solely on pure culture studies particularly difficult. The anaerobic fungus Neocallimastix frontalis has a higher specific activity than the bacteria, with a distinctive metalloprotease activity. The proteolytic activity associated with solids in the rumen may fluctuate according to the degree of colonisation by fungi.

Factors Affecting the Release of Activity from Radioactive Cellulose by Rumen Microorganisms - C. S. Stewart and S. H. Duncan, The Rowett Research Institute, Aberdeen, Scotland.

Cultures of the cellulolytic rumen bacterium Bacteroides succinogenes and of the anaerobic fungus Neocallimastix frontalis were adapted to growth in the presence of various feedlot antibiotics, then tested for their ability to solubilise acid-swollen cellulose that had been reductively tritiated by treatment with tritiated borohydride. Solubilisation of the cellulose was followed by the appearance of radioactive counts in the culture supernates. All of the antibiotics tested reduced the rate of release of tritium by B. succinogenes. For this bacterium the following concentrations of antibiotics reduced attack of cellulose to 50% of the control rate: 5 µg/ml monensin, 50 µg/ml avoparcin, 0.4 µg/ml lasalocid and less than 0.1 µg/ml virginiamycin. Comparable value for the fungus N. frontalis were 2.5 µg/ml monensin, more than 16 µg/ml avoparcin, more than 64 µg/ml virginiamycin and 0.3 µg/ml lasalocid. Both avoparcin and virginiamycin enhanced the rate of release of tritium by N. frontalis. These results suggest that the use of these compounds is likely to influence the contribution of the rumen fungi to cellulose digestion.

Lactate Efflux from Selenomonas ruminantium - R. J. Wallace and J. D. Robertson, The Rowett Research Institute, Aberdeen AB2 9SB, Scotland.

The energy recycling model of Michels et al. (FEMS Microbiol. Lett. 5, 357-362, 1979) predicts that energy conservation may occur via efflux of lactate from bacteria provided that several conditions are met. These conditions have been investigated for lactate efflux from S. ruminantium. The permeability of the lactate anion was insignificant compared to that of the permeant thiocyanate, indicating that undissociated lactic acid was the transported moiety. Furthermore, efflux of lactate was inhibited by PCMB, implying that transport was carrier-mediated, an essential requirement of the model. The stoichiometry of H^+/lactate efflux (n) in growing cells was estimated from the protonmotive force Δp, the transmembrane electrical potential $\Delta\psi$ and the chemical potential of the lactate gradient $\Delta\mu_L$ in these cells. n was close to unity under most conditions, except during the initial stages of batch culture when n = 2 was observed. Hence energy conservation via lactate efflux would be expected only under the latter conditions. Growth yield studies, in which lactate was added to the medium to decrease $\Delta\mu_L$, indicated that the contribution of lactate efflux to total energy production was minor.

Effect of Treatment of Dietary Wheat Straw on Microbial Populations of the Sheep Rumen. Larry Montgomery, Mohammad Zino and Howard Manstield, Dept. of Animal Sciences, University of Illinois, Urbana, IL 61801.

Total viable bacteria and cellulolytic bacteria were enumerated in the rumen contents of sheep fed wheat straw as 33 or 70% of the diet (1, expt. 3). When the dietary wheat straw had been treated with hydrogen peroxide at pH 11.5 (2), the number of cellulolytic bacteria per gram of rumen contents was increased about six-fold ($P<.05$). There was a trend toward a higher cellulolytic count when treated or untreated straw made up 70% of the diet as compared to 33% (Table 1). The total viable count was highest with the 33% treated-straw diet ($P<.05$); there were no signficant differences between counts from the remaining diets. When animals were fed the 70% untreated-straw diet, Ruminococcus albus was the predominant cellulolytic organism in all four animals sampled. With the 70% treated-straw diet, Bacteroides succinogenes was predominant in the three animals sampled. Ruminococcus flavefaciens and B. succinogenes were each predominant in two animals fed the 33% untreated-straw diet, whereas each of the three species was isolated from at least one animal fed the 33% treated-straw diet. Some of the R. albus strains isolated degraded cellulose extremely rapidly in vitro, with the B. succinogenes isolates being the next most effective. Six of the eight B. succinogenes isolates could ferment soluble starch, but none could ferment maltose.

Table 1. Numbers of bacteria ($\times 10^8$) per gram of rumen contents

	Diet			
	33U	70U	33T	70T
Cellulolytic count	0.86[a]	1.61	5.61	10.07
Total viable count	18.7	50.7	242.0	41.1
Percent cellulolytic	5%	3%	2%	25%

[a]Means for four experimental periods, except that no data was available for the 70% diet in the last period.

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Protein and Amino Acid Degradation by Rumen Microbial Enzymes.

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The general information available on proteolytic activity of rumen organisms is summarized. The protease from B. amylophilus was solubilized with zwitterionic detergent and purified by chromatography on ion exchange and hydroxyappatite columns and by preparative electrophoresis. The enzyme has a mol. wt of 120,000; pH optimum 7.4; not inhibited by EDTA; does not require metal ions; has specificity different from trypsin for cleaving oxidized chain of insulin.

A mixture of proteolytic enzymes was extracted from organic solvent treated rumen organisms and fractionated to get a protease preparation with little amino acid degrading activity. The protease (rumen protease) was used for the in vitro determination of feed protein degradability. The ranking of different feed proteins on the basis of degradability by the protease agrees with ranking reported in the literature based on in vivo data. Substitution of S. griseus protease for rumen protease in the assays gave results different from that obtained with rumen protease.

Amino acid degradation was studied with cell-free extracts from M. elsdenii, S. ruminantium and B. fibrisolvens. When single amino acids were incubated with the extracts, ammonia was produced only with threonine, serine, glutamic acid and aspartic acid but not from other amino acids. When a mixture of amino acids was incubated, all amino acids were degraded rapidly by M. elsdenii extracts. Degradation was more at pH 6.8 than at pH 8.4. Threonine degradation was maximum at pH 8.4. Addition of NAD and pyridoxal phosphate increased amino acid degradation several fold. Hydrazine, monensin and lasalocid did not affect the degradation. Diphenyl iodonium chloride decreased the disappearance of several amino acids from the incubation mixture.

Distribution of Ionophore Resistance in Bacterial Groups from the Rumen of Calves Fed Lasalocid and/or Potassium Supplements. K. A. Dawson, W. S. Cain and J. A. Boling, Department of Animal Sciences, University of Kentucky, Lexington, KY 40546-0215.

On hundred and twenty eight bacterial isolates and 48 rumen samples were collected from the rumen of 12 calves being fed rations containing 1% added potassium (added as KCl), added lasalocid (30 mg/kg), both potassium and lasalocid or no additives (control). During the 4-week sampling period, greater molar proportions of propionate and lower proportions of acetate (.17 and .64, respectively) were observed in the rumen of animals receiving lasalocid when compared with those receiving diets without lasalocid (.11 and .68). The addition of potassium to the diet did not alter the effects of lasalocid on ruminal fermentations. The $\log_{10}$ total viable cell counts determined on anaerobic habitat-simulating medium and the percentage of cells enumerated on media containing 10 µg/ml lasalocid averaged 9.65 and 17.0%, respectively, and were not influenced by the addition of potassium and lasalocid to the diet. Approximately 60% of the isolates obtained from animals receiving lasalocid without additional potassium were gram-positive while more than 70% of the isolates obtained from animals in the other three treatment groups were gram-negative. The relative percentage of bacterial isolates resistant to lasalocid averaged 42.9% for all treatment groups and was not affected by the addition of potassium or lasalocid to the diet. However, more gram-negative succinate producers (18 of 60 isolates) were isolated from animals receiving lasalocid than from animals receiving the control and potassium supplemented diets (10 of 68 isolates). Of the succinate-producing isolates obtained from animals receiving lasalocid, 89% were resistant to lasalocid and 79% were resistant to monensin. In contrast, only 33% of the succinate-producing isolates obtained from animals receiving both potassium and lasalocid, and only 50% of the succinate-producing isolates obtained from animals receiving the control and potassium supplemented diets were resistant to lasalocid. These data suggest that lasalocid supplementation increases the relative proportions of ionophore resistant, succinate-producing bacteria in the rumen and that potassium supplementation counteracts the selective activity of lasalocid against this group of bacteria. However, it was not possible to associate increased proportions of ionophore resistant bacteria with changes in the relative proportions of acetate and propionate in the rumens of animals receiving ionophores.

Rumen Bacterial Heat Production in Continuous Culture

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Bacteroides ruminocola strain $B_1 4$ was grown in continuous culture with a medium containing salts, cysteine, yeast extract (0.1 g/l), Trypticase (0.1 g/l), and glucose (5.5 mM). Bacterial heat production was measured with a LKB model 2277 microcalorimeter that was equipped with semiconducting Peltier elements as thermophiles and gold flow cells. Bacterial cells and medium were pumped from the continuous culture vessel through Teflon tubes at a flow rate of 40 ml/h, and total transit time from the continuous culture vessel to the flow cell and back to the culture vessel was approximately 4 min. At dilution rates ranging from .037 to .650 h^{-1} (n=20) succinate and acetate were the primary products and the molar ratio was approximately 1.75. The recoveries of carbon, electrons, energy, and cell dry weight as protein, carbohydrate, RNA, or DNA were 94.4 $\pm$ 1.1, 97.7 $\pm$ 1.3, 105.7 $\pm$ 2.6, and 96.0 $\pm$ 3.2, respectively. As dilution rate increased from .037 to .2 h^{-1}, cell carbohydrate increased from 32 to 41% and protein decreased from 53 to 46%. The relationship between dilution rate and the specific glucose consumption rate was linear (r= .975 for dry weight and r= .937 for protein), and the maintenance rate was .192 m mol glucose/h/g dry weight or .468 m mol glucose/h/g protein. The relationship between dilution rate and the specific heat production rate was not linear. At dilution rates less than .2 h^{-1} heat was produced at a rate of 220 mW/g dry weight or 430 mW/g protein. At dilution rates above .2 h^{-1} glucose accumulated in the culture vessel and the specific rate of heat production more than doubled. Pulse doses of glucose into glucose-limited culture (.167 h^{-1}) caused an immediate increase (approximately 2 fold) in heat production and little increase in cell mass. These data indicated that heat measurements provided a more direct estimate of bacterial maintenance energy and that bacterial maintenance was not necessarily a constant.

NUTRITION

EFFECT OF SUPPLEMENTAL SACCHAROMYCES CEREVISIAE AND/OR ASPERGILLUS ORYZAE ON RUMEN FERMENTATION. R. D. Wiedmeier and M. J. Arambel, Dept. of Animal, Dairy and Veterinary Sciences, Utah State University, Logan, UT.

Studies were conducted to evaluate two viable fungal cultures on rumen fermentation and apparent nutrient digestibility. Four rumen-fistulated Holstein heifers were assigned each of four treatment rations in a 4 X 4 Latin Square design. Treatments included: 1) basal ration; 2) basal ration plus 90 gm/day Saccharomyces cerevisiae (SC); 3) basal ration plus 90 gm/day Aspergillus oryzae/Saccharomyces cerevisiae (AO/SC); and 4) basal ration plus 2.63 gm/day Aspergillus oryzae (AO). Treatments were fed at a rate of 9.0 kg DM of basal ration per day. Animals were adapted to treatments 21 days prior to initiation of the collection period. Chromium-EDTA and chromium-mordanted straw were used to determine liquid dilution and particulate turnover rates, respectively. Apparent nutrient digestibilities were determined using acid-insoluble-ash as an inert internal marker.

Regardless of treatment, there were no significant differences in rumen pH, volatile fatty acid concentration, or liquid dilution and particulate turnover rates. Total rumen cellulolytic and percent cellulolytic bacteria were increased with the addition of the fungal cultures in the diet.

The effect of viable fungal cultures on apparent nutrient digestibility is shown in the following table:

MEASUREMENT	CONTROL	SC	AO/SC	AO	SEM
DM	77.0^{a}	79.1^{a}	81.0^{b}	79.8^{b}	.62
CP	79.5^{c}	82.2^{de}	84.4^{f}	81.6^{d}	.63
ADF	69.3	70.0	72.6	71.0	.89
Hemicellulose	76.3^{a}	80.5^{b}	83.3^{b}	80.8^{b}	1.03

^{ab} P<.05
^{cdef} P<.01

In conclusion, the addition of viable fungal cultures in ruminant diets affected the rumen bacterial population and increased total tract nutrient digestion.

Effects of Nonstructural Carbohydrate and Protein Source on Ruminal Bacterial Protein Synthesis in Continuous Culture. M. D. STERN, M. J. ALLEN, P. M. WINDSCHITL AND W. J. WONG. Dept. of Animal Sci., University of Minnesota, St. Paul, MN 55108.

The effects of total nonstructural carbohydrate (TNC) and protein degradation levels on ruminal bacterial protein synthesis and effluent flow of amino acids were studied using eight dual flow continuous culture fermenters. Four pelleted diets, containing 60% concentrate and 40% forage (DM basis), were formulated to provide two levels of TNC and two levels of ruminal protein degradation. Diets with high and low levels of TNC and protein degradation were attained using corn vs beet pulp and untreated soybeans vs alcohol treated soybeans, respectively. Treatments were arranged in a 2 x 2 factorial design with two experimental periods. Each period was 8 days in duration with the first 5 days serving as a stabilization period followed by 3 days of collection. Because interactions were not observed for ammonia nitrogen (NH_3-N), protein degradation, efficiency of protein synthesis and effluent flow of amino acids (AA), these results are presented in the following table as main effects:

	TNC level		Protein degradation	
Item	High	Low	High	Low
NH_3-N, mg/100 ml[a,b]	17.6	8.9	15.1	11.5
Protein degradation, %	66.2	59.8	65.2	60.9
Bacterial synthesis, gN/kg OMD[a]	32.0	34.9	32.3	34.7
Effluent AA flow, g/d[a,b]	10.9	12.1	11.0	12.0

[a]TNC level effect ($P<.05$).
[b]Protein degradation level effect ($P<.05$).

In contrast to what might be expected, NH_3-N concentration was lower ($P<.05$) for the low TNC diets than the high TNC diets. This effect can be due to lower protein degradation or greater microbial uptake of NH_3-N with the low TNC diets. Protein degradation was lower ($P<.06$), while efficiency of synthesis was higher ($P<.05$) for the low TNC diets. However, total bacterial N in the effluent was not different between levels of TNC or protein degradation. Resistance of beet pulp in the low TNC diets and alcohol treated soybeans in the low protein degradation diets, resulted in higher ($P<.05$) total AA flows. In conclusion, TNC was not an effective measurement for estimating energy availability to rumen microbes. In addition to the ability of beet pulp to supply adequate energy for bacterial protein synthesis, it may also provide a source of protein which is resistant to microbial degradation.

Effects of Cobalt Supplementation on Carbohydrate and Nitrogen Utilization by Ruminal Bacteria in Continuous Culture. M. J. ALLEN AND M. D. STERN. University of Minnesota, St. Paul.

Eight dual-flour continuous culture fermenters were used to study the effects of supplemental cobalt on bacterial carbohydrate and nitrogen digestion. Fermenters were supplied with a diet containing 60% grain mix and 40% forage (DM basis). The diet was formulated to contain 16% crude protein and .3 ppm cobalt. Three cobalt supplements (cobalt glucoheptonate, cobalt dextro-loc and cobalt sulfate) were added to provide an additional 1 mg Co/kg DM intake. Structural and nonstructural carbohydrate digestion (%) as well as crude protein degradation were not affected by addition of the three supplements at 1 ppm cobalt. In a second experiment, cobalt glucoheptonate was supplemented to provide 0, .5, 2 and 10 ppm Co to high and low forage diets. Diets contained 40 or 70% forage with the remaining dry matter consisting of grain. Each diet contained approximately 16.7% crude protein and .2 ppm cobalt. Supplementing cobalt at 10 ppm increased ($P<.05$) vitamin B_{12} synthesis (µg/d), in both high and low forage diets. Results from this experiment are shown in the following table:

Digestion	Cobalt Level (ppm)			
	0	.5	2	10
	----------%			----------
Organic matter, true	55.6	53.9	50.0	54.5
Neutral detergent fiber	35.7[b]	33.8[b]	33.2[b]	43.7[a]
Acid detergent fiber	38.9[b]	37.7[b]	38.4[b]	46.8[a]
Total nonstructural carbohydrate	88.2	89.5	87.5	88.1
Crude protein	73.1	69.4	59.4	65.0

[a,b]Means in same row with uncommon superscripts differ ($P<.05$).

Supplementing cobalt from various sources at 1 ppm had no effect on carbohydrate or protein utilization. Supplementing cobalt at 10 ppm as cobalt glucoheptonate increased ($P<.05$) vitamin B_{12} synthesis, neutral detergent fiber and acid detergent fiber digestion (%) in both high and low forage diets.

Lactational and systemic responses of high producing dairy cows to the addition of protected methionine in soybean meal diets. D. J. Illg, J. L. Sommerfeldt, D. J. Schingoethe, South Dakota State University, Brookings.

Rumen-protected methionine was supplemented to soybean meal diets to evaluate the response of lactational and systemic parameters. Twenty-seven Holstein cows (14 primiparous and 13 multiparous) were randomly assigned to either soybean meal (SBM) or soybean meal plus 15 g protected DL-methionine (SBM +) diets. Cows were fed experimental diets wk 4 through wk 16 postpartum with pretreatment milk production and composition (wk 3 postpartum) used as covariants for statistical analysis. Cows were fed mixed diets of (dry matter basis) 30% corn silage, 15% chopped alfalfa hay, and 55% concentrate mix. Diets were formulated to be 16.0% crude protein and 18.0% acid detergent fiber. Milk (32.9 and 35.2 kg/day), 4% fat corrected milk (27.8 and 29.5 kg/day), and solids corrected milk (28.2 and 30.1 kg/day) yields were higher for SBM + cows than SBM cows. Milk protein percentage (2.99 and 3.06) was increased in the SBM + cows. The percentages of total solids (11.67 and 11.71), fat (2.96 and 3.00), and solids-not-fat (8.69 and 8.73) were similar among diets. Dry matter intake (19.3 and 21.3 kg/day) was higher for the SBM + cows while production efficiency (1.74 and 1.69 kg milk/kg dry matter) was not different. Serum urea, ruminal fluid pH, ruminal ammonia and molar concentrations of acetate, propionate, and butyrate were similar between diets. Milk production and milk protein percentage were increased with the addition of 15 g of protected DL-methionine.

Key words: protected methionine, lactating cows.

Influence of bacterial nitrogen contamination on in situ nitrogen digestion of forages stored at different dry matters. J. E. Nocek and A. L. Grant. Research and Development Dept., Agway Inc., Syracuse, NY 13221

Four forages; alfalfa (ALF), clover (CL), orchard grass (OG) and timothy (TIM) were sun cured to yield the following dry matter (DM) percentages for each forage: Hay (89%), 60%, 40% and 20% (direct cut). The 60, 40 and 20% DM materials were chopped (1-2 cm), and approximately 30 kg of each were compacted into double lined plastic bags and sealed for approximately 3 wk. Core samples were air dried, and ground (5 mm). A cannulated lactating cow, consuming 50% of her DM intake from hay crop silage was used to measure in situ nitrogen (N) disappearance. Polyester bags for in situ determinations were 9 x 22 cm, with 5 g dry forage weight per bag (59μ pore size). Ruminal incubation times were 1, 2, 3, 4, 6, 8, 12, 16, 28, 40, 52, 76 and 100 h. Bags were presoaked in 39^{0}C water for 15 min. prior to ruminal suspension. Regressions were corrected for N washout, lag and undigested residue. If no significant ($P<.05$) quadratic component was present, regression analysis was conducted on the natural lag transformed residues. If a significant quadratic component was present, curve peeling was conducted and, fast and slow digestion rates were determined. Each time point residue was analyzed for diaminopimelic acid (DAPA) to corrected for bacterial-N contamination. The corrected residues were once again subjected to regression analysis.

Soluble and 59μ filterable N increased linearly as preservation dry matter decreased for ALF, CL and OG. Ruminal undigestible N followed this same trend of ALF and CLO. Trends for time related bacterial-N contamination was variable for forages and preservation DM levels. There was a tendency for bacterial-N to peak and either plateau or decline as a percent of total residual-N with ruminal incubation time. Bacterial-N contamination regressed on time of ruminal incubation yielded linear and quadratic profiles (except for OG) for each forage type. This suggests that bacterial contamination appears to be a function of attachment site availability.

Correcting residual nitrogen at each incubation time for bacterial-N contamination resulted in the reduction of digestion lag times for all but four treatments. Correction for bacterial-N contamination had a variable effect on digestion rates for forage type and preservation DM. Some regression profiles tended to be described more appropriately by one linear rate after correction, especially for OG.

Estimation of bacterial-N contamination should be considered when establishing ruminal N digestibility rates for forages determined by in situ procedures.

Concentration and Flow of Peptides from the Rumen of Cattle Fed Different Amounts and Types of Protein

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Peptides were quantitated in rumen fluid using a perchloric acid/ninhydrin method. Preliminary experiments indicated that protein hydrolyzates and the peptide, insulin (M.W. 6000), were recovered quantitatively. In vitro studies (Russell, et al., 1983) had indicated that casein hydrolysis was associated with the formation of a large peptide pool that turned over slowly. It was the purpose of these studies to examine the effect of changes in protein degradability on peptide flow from the rumen of lactating cattle. First-lactation, rumen-cannulated Holstein cows were used in a series of Latin square experiments. In the first experiment the cows were fed a blended ration containing 14, 17, or 20% crude protein 12 times a day. Solvent-extracted soybean meal (SBM) provided 60% of the total protein, while the remainder of the protein was derived from corn silage, hay silage, and barley. In the second experiment the protein content was once again 14, 17, or 20%, however, the SBM was autoclaved for 20 min (121 C). During the third experiment the protein content was standardized at 17%, the cows were fed once a day, and the diets contained SBM, 50:50 SBM, and extruded soybean meal (ESBM), or 50:50 SBM and fish meal (FM). Rumen volume and fluid dilution rates were calculated from the disappearance of Co EDTA.

In the first set of experiments the cows were fed 12 times daily and the rumen volumes (54 - 56 l) and dilution rates (.163 - .172 h^{-1}) remained relatively constant. Peptide concentrations were 568, 826, and 803 mg/l at 14, 17, and 20% protein, respectively. By multiplying the concentration, volume, and dilution rate, the peptide flow was estimated as 118, 179, and 181 g/day, respectively. The two highest values were not statistically different, but both of them differed from 118 (p .05). In the second set of experiments the cows were once again fed 12 times a day, but the SBM was heated to decrease degradability. In this case, the peptide flows were 102, 138, and 167 g/day, respectively, and all the differences were significant (p .05). In the last set of experiments, the cows were fed once a day and the rumen volumes, dilution rates, and peptide concentrations differed greatly. Peptide flow was calculated by integration. Instantaneous volumes and dilution rates were calculated from the 1st derivative of Co EDTA disappearance and concentration was estimated by regression. Peptide flow was 101, 73, and 80 g/day for the SBM, ESBM/SBM, and FM/SBM, respectively. These experiments indicated that peptide flow from the rumen is affected by the type and amount of protein in the ration. However, in all cases peptide flow was still significant.

Effect of Dietary Protein Level on Nitrogen Metabolism in Sheep: Studies Using ^{15}N-Nitrogen. L. D. BUNTING, J. A. BOLING, C. T. MacKOWN and R. B. MUNTIFERING, Department of Animal Science, University of Kentucky, Lexington, KY 40546.

Six ruminally and abomasally cannulated wether lambs (30 kg) were used in randomized design experiment to determine the effect of dietary protein level on nitrogen (N) metabolism utilizing isotope dilution techniques. Dietary treatments were: High N intake (21 g N/d), and Low N intake (12 g N/d). Lambs were fed 850 g/d of a pelleted diet (75% corn-soy, 25% cottonseed hulls) offered in equal portions 24X daily. Single injections of ^{15}N-labelled compounds were introduced into the rumen NH_3 and blood urea pools, and non-compartmental analysis was used to estimate the rate of flux through, and transfer of N between these and other N pools. These estimates were compared to N balance measurements and recovery of N at the abomasum.

Although lambs on High N diets retained more ($P<.001$) N, there was no significant ($P>.05$) affect on N recovered at the abomasum. Lambs consuming Low N diets had less ($P<.05$) apparent ruminal NH_3 loss (BUN derived from rumen NH_3) and greater ($P<.10$) recapture of N from blood urea (microbial N from BUN). This finding suggests that significant capture of N from blood urea by rumen bacteria may occur when bacterial growth is limited by low rumen NH_3 concentrations. The results were as follows:

Item	Diet	
	High N	Low N
N retained, g/d	9.5	4.2
N at abomasum, g/d	17.8	13.9
BUN derived from rumen NH_3, g/d	3.1	.5
Microbial N derived from BUN, g/d	2.6	5.5

Ammonia treatment of high-tannin peanut skins in beef cattle diets. G. M. HILL, P. R. UTLEY and G. L. NEWTON, Dept. of Animal Sci., University of Georgia, Coastal Plain Sta., Tifton 31793.

Potential methods of reducing detrimental effects of peanut skin (PS) tannins on nutrient digestibility and performance of beef cattle were evaluated which included urea supplementation of PS diets and ammonia treatment of PS. Anhydrous ammonia was injected into large plastic bags at 3% of PS weight, bags remained sealed for 10 to 14 d, and ammoniated peanut skins (APS) were air equilibrated for 7 d prior to diet formulation. Percentages of dry matter (DM), ether extract (EE), crude fiber (CF), crude protein (CP) and tannin (T), respectively, for untreated PS and APS, were: DM 93.1, 90.4; EE 21.0, 21.0; CF 14.7, 13.7; CP 17.7, 27.0; T 20.5, 12.0. Three dietary treatments were fed to six metabolism steers (3x3 Latin square, daily feed restricted to 4.54 kg/steer), to 18 individually-fed heifers (ad libitum intake, 84-d trial) and to 54 feedlot steers (ad libitum intake, 98-d or 147-d feedlot period). The control diets without PS (C), urea supplemented PS diets (UPS) and diets with ammoniated PS (APS) contained corn, peanut skins, soybean meal, and urea at these respective percentages: C 81.5, 0, 7.7, 0; UPS 73.6, 15.0, 0, .6; APS 73.7, 15.5, 0, 0; and, all diets contained peanut hulls (10%), $CaCO_3$ (.5%) and trace mineral salt (.3%). Dietary DM, EE, CP and T percentages, respectively, were: C 88.9, 3.3, 13.2, 1.1; UPS 89.7, 6.1, 12.7, 4.1; APS 89.6, 6.2, 12.4, 3.2. Apparent digestibility (%) of DM, EE, CP, nitrogen-free extract (NFE) and digestible energy (DE) were: C 79.0, 76.5, 72.4, 88.4, 76.3; UPS 62.5, 90.3, 44.4, 71.3, 60.5; APS 59.0, 87.8, 37.9, 68.1, 56.4; and digestibility of DM, CP, NFE and DE were higher ($P<.05$) for C compared with UPS and APS. Digestibility of EE was higher ($P<.05$) for UPS and APS compared with C., Nitrogen (N) intake, fecal N, urinary N and retained N (g/d), respectively, were: C 86.1, 23.7, 34.8, 27.5; UPS 83.1, 46.2, 27.7, 9.2; APS 81.6, 50.8, 23.7, 7.2; and fecal N was higher ($P<.05$) on UPS and APS diets compared with C which contributed to lower ($P<.05$) urinary N and retained N for UPS and APS diets. Similar ($P>.05$) 84 d final weights (FW), average daily gains (ADG) average daily feed (ADFD), carcass weights (CW) were recorded for individually fed heifers on respective treatments: C 452, 1.27, 9.5, 281; UPS 441, 1.14, 9.5, 264; APS 447, 1.20, 9.7, 269. Rumen fluid acetic, propionic and butyric acids (molar %), rumen fluid pH and plasma urea nitrogen (PUN mg/dl) at 3 h and 6 h postfeeding, respectively, on d 62 were: C 49.6, 47.7, 37.7, 36.7, 8.9, 9.7, 5.6, 6.0, 14.0, 14.0; UPS 53.9, 52.4, 29.5, 29.4, 13.6, 14.8, 5.7, 6.0, 9.2, 8.3; APS 49.7, 48.8, 34.9, 36.1, 11.9, 11.8, 6.0, 9.0, 10.2. Butyric was lower ($P<.05$) at 6 h for C compared with UPS; and PUN was higher ($P<.05$) at 3 h and 6 h for C compared with UPS and APS. On d 98 the respective FW, ADG, ADFD (kg) and F/G of feedlot steers were: C 495, 1.38, 10.2, 7.4; UPS 462, 1.04, 11.6, 11.3; APS 492, 1.35, 12.3, 9.1; and, FW and ADG were higher ($P<.05$) for C and APS compared with UPS. After 98 d CW (kg) and percentage U.S. Choice carcasses on respective C and APS treatments were: 295, 289; 72.2, 72.2. Steers fed UPS remained on trial and their 147-d FW, ADG, ADFD, F/G, CW (kg) and percentage Choice carcasses, respectively, were: 50.9, 1.02, 11.5, 11.3, 313, 100. Digestibility and N retention were not improved in steers fed a urea supplemented PS diet or an APS diet at restricted intake. Ad libitum feeding of the APS diet was effective in overcoming detrimental effects of PS tannins on feedlot performance of steers and heifers.

Utilization of nitrogen and ammonia-treated straws. J. R. MALES and D. DEAVILA, Dept. of Animal Sciences, Washington State University, Pullman, WA 99164-6320.

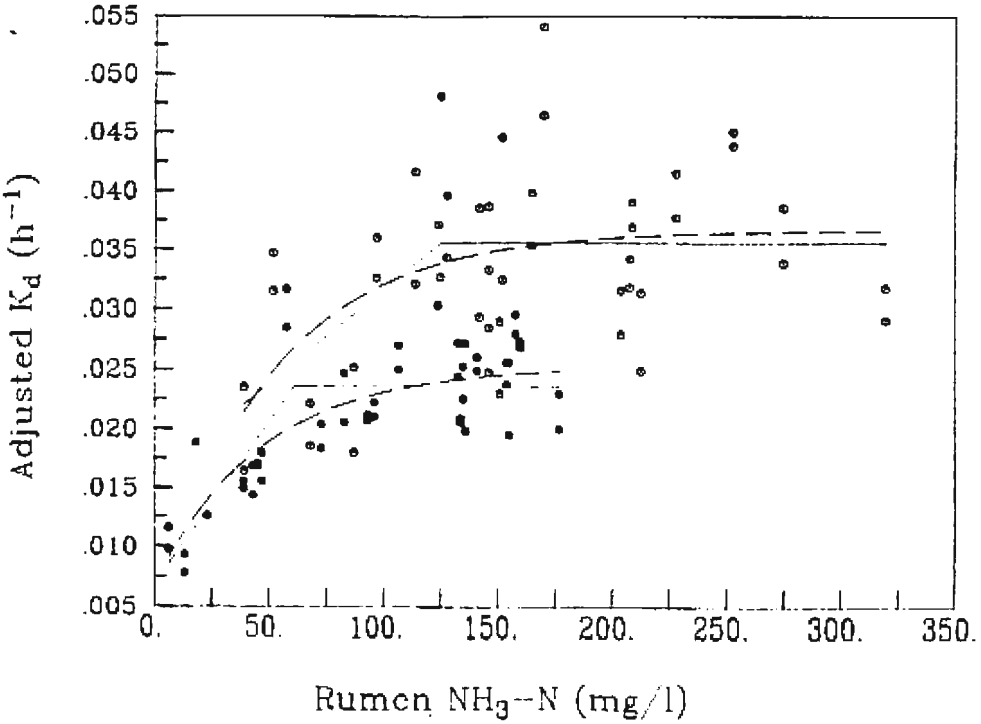
Chemical treatment of straws with anhydrous ammonia has resulted in an increased organic matter digestibility and crude protein content of the treated product. The amount of the added ammonia-N that can be utilized by rumen bacteria and is thus available to the animal as microbial protein is not known. In vivo, 25% of the nitrogen in NH_3 treated straw is associated with the acid detergent insoluble portion of the straw. A series of experiments was designed to determine the nitrogen availability of ammonia treated straw diets in nitrogen balance studies in a steer growth trial. In a preliminary study, a 4 X 4 Latin square nitrogen balance study evaluated 70% ammonia treated straw diets supplemented with no protein, low soybean meal, high soybean meal or dehydrated alfalfa meal plus urea. All 3 protein supplements were formulated to raise the dietary crude protein level to 12%. Protein supplementation increased nitrogen retention from 2.7 to 4.25, 4.10 and 7.62 g/day for the four treatments respectively. (The response to protein was significant ($P<.05$.) In a second nitrogen balance experiment, in a 4 X 4 Latin square design using four lambs per square, the four treatments were isocaloric 60% ammonia treated straw diets with 22% steam rolled corn and 18% supplement which were: 1) no additional crude protein; 2) 1.5% added dietary crude protein; 3) 3% added dietary crude protein; 4) 4.5% added dietary crude protein. Nitrogen retention was 2.57, 3.86, 4.31 and 4.55 g/day for the four supplements, respectively. There was a linear ($P<.01$) response to protein. One hundred sixty-two steer calves were randomly allotted to 18 pens and fed in a 2 X 3 factorial design of treatments. Ammonia treated barley straw was compared to ammonia treated wheat straw and 3 protein supplements (28, 39, and 50% CP) were compared. The protein supplements were fed at the level of .9 kg/head/day. Steam rolled barley was fed at the rate of 1.8 kg/head/day for the first 28 days and 3.2 kg/head/day for the final 56 days. The appropriate ammonia treated straw was fed ad libitum. There was no difference in performance in steers fed the ammonia treated wheat and barley straw. However, gains were .57, .55 and .65 kg per steer per day for the 3 protein supplements, respectively with the 50% CP supplement different ($P<.01$). Feed per gain were 12.2, 12.7 and 10.8 kg per head for the 3 supplements with the 50% CP supplement different ($P<.01$). Results of the nitrogen balance studies and the animal growth trial indicate that approximately one third of the nitrogen in the ammonia treated straws is not being utilized for microbial protein synthesis. Therefore, a crude protein value one third lower than the chemical analysis would indicate should be used for balancing rations which contain ammonia treated straws.

Influence of Rumen Ammonia Concentration on in Situ Fractional Degradation Rates of Barley and Corn. J. Odle, D.M. Schaefer, and J.W. Costerton, University of Wisconsin-Madison and University of Calgary.

Reported estimates of optimal rumen ammonia concentration (RAC) vary considerably, ranging from a low of 14 to a high in excess of 200 mg NH_3-N/l. We hypothesized that a portion of this variation could be attributed to the type of degradable substrates provided to the rumen microorganisms. Therefore, the objective of this experiment was to determine if the optimal RAC differs for barley and corn substrates.

Four ruminally cannulated steers were fed barley and corn diets supplemented with graded levels of an ammonium acetate solution. Animals were fed hourly from automatic feeders, and water consumption was controlled to achieve steady-state rumen fermentations. Dacron bags containing rolled barley and ground barley were incubated in the rumens of barley-fed steers, while ground corn and autoclaved corn were incubated in the rumens of corn-fed steers. Dry matter fractional degradation rates for each bag substrate were estimated using a single pool exponential decay model.

Differences in degradation rate due to processing method were not detected; however, barley was degraded at a faster rate than corn. Furthermore, the figure below shows that the minimal rumen NH_3-N concentration required to maximize the degradation rate of barley (o; 125 mg/l) was greater than that required to maximize the degradation rate of corn (•; 61 mg/l). These results indicate that the optimal rumen NH_3-N concentration was different for the barley and corn diets. This is taken as evidence that estimates of optimal rumen NH_3-N concentration are influenced by characteristics of the degradable substrate. Transmission electron microscopy of barley and corn particles incubated *in situ* for 7h revealed a morphologically diverse and multi-layered adherent bacterial population. The observed results may be due to differences in penetrance of NH_3-N into the adherent populations.



EFFECTS OF DIET CONCENTRATE LEVEL AND SODIUM BICARBONATE ON SITE AND EXTENT OF FORAGE FIBER DIGESTION IN THE GASTROINTESTINAL TRACT OF WETHERS

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Four adult wethers (45 kg) with permanent rumen and abomasal cannulae were used in a repeated measures Latin square arrangement of treatments to quantitate the effects of diet concentrate level and sodium bicarbonate ($NaHCO_3$) on site and extent of forage fiber digestion in the gastrointestinal tract. Experimental diets consisted of mature Kentucky-31 tall fescue hay, soybean meal and a semi-purified concentrate mixture in ratios of 95:5:0, 76:4:20, 57:3:40 and 38:2:60; $NaHCO_3$ represented 0 or 7.5% of the concentrate mixture. Ruminal digestion (% of intake) of neutral detergent fiber (NDF) and hemicellulose decreased linearly ($P<.05$), whereas acid detergent fiber (ADF) digestion responded in a cubic ($P<.05$) fashion to increasing concentrate level; $NaHCO_3$ improved ruminal digestion of NDF ($P<.10$) and ADF ($P<.05$), but not hemicellulose. Postruminal digestion (% of rumen undegraded) of NDF and ADF tended to increase, whereas hemicellulose digestion responded in a cubic ($P<.05$) fashion to increasing concentrate level; $NaHCO_3$ decreased ($P<.05$) postruminal digestion of all fiber fractions. Total tract digestion of NDF and ADF showed a cubic ($P<.05$) response, whereas hemicellulose digestion responded in a quadratic ($P<.05$) fashion to increasing concentrate level; $NaHCO_3$ had no effect on total tract digestion of any fiber fraction. Ruminal hemicellulose digestion was correlated with mean pH ($r=.30$; $P=.09$) and minimum pH ($r=.33$; $P=.07$) attained in a 24-h feeding cycle. Path coefficient analysis revealed forage hemicellulose degradability was more pH-sensitive and less responsive to $NaHCO_3$ than ADF degradability when concentrate was fed. Results indicate that concentrate feeding and $NaHCO_3$ alter the primary sites of forage fiber digestion in the gastrointestinal tract, but do not systematically influence the extent of total tract utilization.

Mineral absorption and balance in ruminants fed monensin. L. W. GREENE, G. T. SCHELLING and F. M. BYERS, Dept. of Animal Sci., Texas A&M Univ. and Texas Agr. Exp. Sta., College Station, TX 77843.

Three experiments were conducted to determine the effect of monensin on mineral absorption and balance. During experiment 1, two trials were conducted to determine the effect of monensin on the apparent absorption and retention of Mg, P, Ca and Zn. Eight lambs (39 kg) were used in trial 1, and 10 lambs (37 kg) were used in trial 2: Animals were blocked by weight and fed a high concentrate diet with or without 20 mg/kg monensin. Trials began with a dietary adjustment period lasting 18 d in trial 1 and 21 d in trial 2. Animals were then placed in metabolism stalls for a 10 d stall adjustment period followed by a 10 d collection period. Monensin supplementation increased ($P<.05$) Mg retention 42.0%. Urinary Ca excretion decreased ($P<.05$) 60.0% when monensin was fed. Apparent P digestibility ($P<.05$) and retention ($P<.10$) increased due to monensin supplementation. Both apparent absorption and retention of Zn increased ($P<.01$) 50.0 and 45.0%, respectively, with monensin supplementation. Sodium retention decreased ($P<.05$) 86.2% when monensin was fed. Apparent K absorption increased ($P<.05$) 16.7%, while K retention increased ($P<.10$) 52.6% when monensin was fed.

During experiment 2, twelve ruminally cannulated lambs (31 kg) were used in three balance trials in a 2 x 3 factorial arrangement to determine the effect of monensin and potassium on Mg balance. Lambs were randomly assigned to two groups and fed a basal diet containing .44% K with or without 20 mg/kg monensin for an 18 d adjustment period. Following the adjustment period, lambs were placed in individual metabolism stalls, fed twice daily 450 g of their respective diet, and infused ruminally with 0, 7.6 or 31.6 g K/d (equal amounts at each feeding in 158 ml of distilled-deionized water). During each trial, animals were re-allotted to K level with the restriction that they would not receive the same level during two trials. Each trial consisted of a 15 d preliminary period and a 10 d collection period. Addition of monensin to the diet decreased ($P<.05$) fecal and urinary Mg excretion 15.9 and 15.5%, respectively. Apparent absorption and retention of Mg were increased ($P<.05$) with the addition of monensin. Increasing K level increased ($P<.05$) fecal Mg and decreased urinary Mg. Apparent absorption of Mg decreased from .93 to .80 g/d when either level of K was infused into the rumen.

During experiment 3, eight crossbred steers (350 kg) with duodenal and ileal cannulae were used in two trials to determine the effect of monensin on Mg, Ca and Zn digestibility at different sites of the digestive tract. Steers were housed in individual concrete-floored pens and fed 4.5 kg of a cottonseed hull:concentrate diet (30:70) with or without 20 mg/kg monensin and with .25% chromic oxide at 0800 and 1700 h daily. Each trial consisted of a 10 d diet adjustment, a 7 d preliminary and a 6 d collection period. During trial 2, steers were assigned to the diet they did not receive in trial 1. Apparent Mg digestibility increased ($P<.05$) when monensin was fed. This increase was due to a 52% increase in apparent Mg digestibility in the preintestinal region. Apparent Mg digestibility in the small intestine was negative and greater ($P<.05$) when monensin was fed. Addition of monensin did not alter apparent Ca digestibility. Apparent Zn digestibility was increased ($P<.05$) when monensin was fed. These data indicate that mineral digestibility is altered in cattle consuming monensin.

Relationship of rate of dissolution of magnesium oxide to excretion of magnesium in cattle. L.J. Wheeler, C.H. Noller and J.A. Patterson. Dept. of Animal Sciences, Purdue University, West Lafayette, IN.

Twenty-four Holstein heifers, average weight of 376 kg, were used in a continuous trial to compare excretion patterns in urine and feces when either a fine (A) or a coarse (B) magnesium oxide was fed. Magnesium oxides A and B had T 50's of 15 and 500 minutes, respectively, and quick reactivities of 58 and 5% of the H+ neutralized, respectively. When fed to ruminally-fistulated animals, the fine magnesium oxide (A) produced much higher concentrations of magnesium in the ruminal fluid, indicating a higher degree of dissolution than the coarse material (B). All animals were fed 3.0 kg corn silage dry matter, .32 kg protein-mineral supplement, and 2 g chromium sesquoxide twice daily, beginning 7 days prior to the treatment period. During the 14-day treatment phase, animals received either 1) control diet, 2) control plus 76 g MgO-A, or 3) control diet plus 76 g of MgO-B. All animals were returned to the control diet for days 15-21. Urine was sampled once and feces twice daily for 21 days. Urine was analyzed for magnesium and creatinine and feces for magnesium and chromium. Daily urinary and fecal magnesium excretions were calculated. Control animals excreted a fairly steady rate of 3 g Mg/day in the urine and 10 g/day in the feces. Urinary magnesium increased to 9 g/day for treatment 2 and 6 g/day for treatment 3. In the post-treatment period, treatment 2 decreased to control levels in less than 7 days while treatment 3 decreased more slowly and had not reached control levels on day 21. Fecal magnesium excretion increased more rapidly for treatment 2 than 3, although both reached the same level by day 5. When supplementation ceased fecal magnesium excretion for animals on treatment 2 fell to control levels in 7 days, while those on treatment 3 had not reached control level by day 21. Increased rates of dissolution of magnesium oxides in vitro were reflected by higher concentrations of magnesium in ruminal fluid, higher losses via urine and more rapid excretion in feces.

Predicting B Vitamin Supply to the Small Intestine of Cattle. R. A. Zinn, F. N. Owens, R. L. Stuart, J. R. Dunbar, and B. B. Norman. University of California, Davis.

Three crossbred calves (194 kg) with cannulas in the rumen and proximal duodenum were used in a 3x3 Latin square experiment to study the influence of B-vitamins plus ascorbic acid supplementation on characteristics of digestion. Dietary treatments consisted of a basal diet (55% concentrate) supplemented to provide 0, 1, or 10X the recommended B-vitamin requirement for the growing pig adjusted to an equivalent body size. Experimental diets were meal-fed at equal intervals twice daily. Estimates of digestion were based on composites of duodenal and fecal spot samples, using chromic oxide as a marker. Differences in site of digestion across vitamin treatments were small and non-significant ($P>.20$). Ruminal digestion of OM, ADF, and N averaged 49, 26, and 41%, while total tract digestion for the same components averaged 73, 38, and 69%, respectively. Net microbial synthesis was virtually identical across treatments. In general, lower level vitamin supplementation caused small increases in flow of vitamin to the small intestine ($P>.20$). At the higher levels of supplementation, intestinal supply increased for all vitamins except B_{12} and ascorbic acid. B_{12} recovery remained constant across treatment. No ascorbic acid was detected at the proximal duodenum at any level of supplementation. Ruminal bypass of thiamin, riboflavin, niacin, B_6, pantothenic acid, folic acid, biotin, and B_{12} averaged 52.3, 1.2, 6.2, 101.0, 22.1, 2.7, 132.5, and 10%, net microbial synthesis of the same vitamins averaged 8.3, 15.2, 107.2, 5.6, 2.2, .42, .79, and 4.1 mg/kg digestible OM, respectively. The usefulness of these estimates for predicting B-vitamin supply to the small intestine was tested in a second trial involving 4 steers (250 kg) while cannulas in the rumen, proximal duodenum, and distal ileam. Treatments consisted of an 80% concentrate diet fed at levels of 1.2, 1.5, 1.8, and 2.1% of body weight. Chromic oxide was used as a digestion marker. Predicted values for B-vitamin recovery at the proximal duodenum showed excellent agreement ($\pm$6%) for thiamin, riboflavin, and B_{12}, though flows were somewhat overpredicted for niacin and B_6 (137 and 144% of expected, respectively).

Proposed Mechanism of Action for Depressed Dry Matter Intake with Wet Forages - J. R. Carpenter and R. Y. Nino-DuPont, Univ. of HI, Honolulu and J. G. Welch, Univ. of VT, Burlington.

Livestock producers and dairymen continue to shift to forages that can be harvested, handled, stored and fed automatically while maintaining high nutrient quality. As a result, rations are becoming higher in moisture, and voluntary intake is exceedingly more difficult to predict. Wet rations are known to limit dry matter intake (Beltsville, Cornell, Illinois, Minnesota, Ohio and Wisconsin). Results indicate that cattle consume 0.01 to 0.03 Kg less DM per 100 Kg body weight for each 1% rise in moisture content. Most researchers suggest that the depression in dry matter intake with higher moisture content does not appear to be due to water itself, but rather to limited physical capacity (energy/nutrient density), acidity within the reticulo-rumen or other chemical compounds produced either during rumen fermentation or the ensiling of these wet forages. Physical events relating to particle size reduction of digestible fiber in the rumen are important in regulating roughage intake, and hence, is the limiting process in clearing of indigestible fibers from the rumen. Rumination plays a major role in this process. Particulate disappearance in the rumen is affected by particle comminution, rate of hydration, change of specific gravity within the rumen, rates of digestion and passage, and average retention time. Alfalfa harvested as hay (87.2% DM), haylage (58.2% DM) and silage (47.4% DM), trts 1-3 respectively, were fed ad libitum to both rams and fistulated steers. The average pH's and % lactic acid of the ensiled materials was 5.35^{y}, 0.65^{y}; and 4.92^{x}, 3.23^{y} for trts 2 & 3, respectively. Dry matter and protein digestibility did not differ but the CWC and ADF digestibilities were significantly higher for the hay than either of the fermented forages ($P<.01$). Rate and extent of protein and dry matter digestion in situ also differed ($P<.05$). Continuous jaw motion recordings were taken with the Finn rams to determine rumination time; and wet sheep and steer feces were sieved through 2400, 1200, 600 and 300 µm screens to determine fecal particle size. Sheep rumination data for trts 1-3, respectively, were: rumination (mins/day) 410^{a}, 476^{b}, 537^{c} and rumination (mins/kg of CWC) 434^{x}, 566^{y}, and 658^{z}. Rumen samples were taken from steers 1, 2, 4, 6, 8 and 12 hrs after both AM and PM feedings. Average pH's were 6.68, 6.63 and 6.60 for trts 1-3, respectively. Differences were significant ($P<.05$) at only 1, 2 and 4 hrs after the evening feeding. Specific gravity of rumen fluid was lower ($P<.01$) at 8 and 12 hrs after the AM feeding and 1, 2, 4, 6 and 8 hrs after the PM feeding when steers were fed long hay. Specific gravities of the rumen fluid were 1.0055, 1.0067 and 1.0065 for trts 1-3, respectively. Wet silages sank faster in the rumen, were less efficiently ruminated, altered rumen viscosity (stratification) resulting in an apparent increased fill factor and caused larger particles to be passed to the feces. Both mastication and fermentation in the rumen play a very important role in particle size reduction. The degree to which microbial action may enhance rumination effectiveness through increased fragility of digesta particles and the efficiency that boluses are masticated during rumination requires further study. Means with different superscripts differ (a,b,c = $P<.05$; x,y,z = $P<.01$).

In Situ Evaluation of Processing and Lipid Effects on Soybean Protein Disappearance. G. M. DAVENPORT, J. A. BOLING, L. D. BUNTING, and N. GAY, Department of Animal Science, University of Kentucky, Lexington, KY 40546.

The effects of soybean processing and soybean lipid on ruminal soybean protein degradation were evaluated using in situ techniques. The treatments were: (1) commercially processed soybean meal (SBM), (2) ground whole soybeans (GSB), and (3) SBM coated with 12 percent soybean oil (SBMO). Resistance to ruminal degradation was based on in situ rate of nitrogen disappearance. Residual microbial contamination was estimated using nucleic acid nitrogen as the microbial marker.

The experimental design consisted of two ruminally cannulated steers and two sampling days. A basal diet of corn silage (6.8 kg/d) and SBM (.36 kg/d) formulated to contain 12 percent crude protein (DM basis) was fed in equal portions twice daily (12 h intervals). Approximately 10 g of each treatment were placed in individual nylon bags (7.5 x 15 cm and 50-70 micron porosity). Twenty one nylon bags, representing 7 bags per treatment, were attached to a stainless steel chain (.80 kg) and placed in the ventral sac of the rumen. One bag per treatment was removed 1, 2, 3, 4, 6, 8 and 12 h postfeeding. Ruminal fluid was collected at each sampling time to harvest microbes by differential centrifugation. Composited microbial pellets had a nucleic acid nitrogen to total nitrogen ratio of .21.

Disappearance rates (percent per hour) for total nitrogen and microbial corrected nitrogen were as follows: SBM 1.4, 1.8; GSB 4.0, 3.1; SBMO 1.2, 1.4. Microbial colonization of GSB occurred within 1 h of incubation, whereas SBM and SBMO were more resistant to attachment through 4 h. After 4 h, colonization of GSB decreased, while increases were observed for SBM and SBMO. SBMO appeared to be more resistant to microbial attachment than SBM. Increases in microbial colonization of SBM and SBMO caused the rates of dietary nitrogen disappearance to be underestimated. The rate of GSB nitrogen disappearance was overestimated due to loss of dietary and microbial nitrogen.

These data suggest that solvent extraction processing methods are more effective than soybean oil coating in reducing ruminal protein degradation. GSB was colonized more rapidly than SBM and SBMO, resulting in faster ($P<.001$) and more extensive protein degradation. Lipid coating appeared to inhibit microbial attachment to SBM and tended to reduce ($P<.14$) the rate of nitrogen disappearance when residual dietary nitrogen was corrected for microbial contamination.

Effects of Isoacids on Rumen Fermentation and Plasma Hormone Levels in Sheep - A. V. Brondani and R. M. Cook, Michigan State University, East Lansing, MI.

Two trials were conducted to study the effects of isoacids (isobutyrate, 2-methylbutyrate, isovalerate, valerate), urea and sulfur on rumen fermentation of sheep fed diets based on agricultural by-products. Basal diets consisted of 25% corn stover, 25% corn cobs, 49% sorghun grain, 1% mineral mix (Trial I) and 44% sugarcane bagasse, 55% sorghun grain, 1% mineral mix (Trial II). Each trial consisted of a 2x2x2 factorial crossover conducted in two 4x4 quasi-latin squares. Eight rumen-cannulated adult sheep were divided in two groups according to body weight (25 and 30 kg) and randomly assigned to the squares. Each animal was fed four of the eight treatment combinations during 14-day periods. Acetate production was determined using a single injection of 1-C14 acetate plus PEG for volume measurements on day 14 of each period. Overall, feeding isoacids increased the rate of acetate production by 24% (Trial I, $p<.05$) and 32% (Trial II, $p<.01$). In both trials, this increase was dependent upon the level of urea, but independent on the level of sulfur in the diet.

Recent reports have indicated that isoacids affect the plasma hormone levels in lactating dairy cows. In this experiment, the effect of isoacids on plasma hormone levels in adult sheep was studied. Six aged ewes (bw=40 kg) were used in a 3-period crossover design. Animals received 1200 g alfalfa hay/day fed in two portions (0800 and 1600 h). Treatments were 0 (control), 0.1 (ISO-1), and 0.2 (ISO-2) g isoacids/kg/bw/day, placed directly into the rumen immediately following feeding. On day 14 of each period, blood samples were collected prior to morning feeding and then every 30 minutes for the next 12 hours. Plasma levels of cortisol, glucose, and urea were not affected by isoacids. The decrease in growth hormone following feeding was less pronounced in the ISO-2 group, but these differences were not significant ($p<.20$). Animals fed ISO-2 had lower mean plasma levels of insulin relative to control (19.7 vs. 24.9 uU/ml, $p<.05$). The results of these two studies suggest that the positive effects of isoacids on animal performance are due to an increase in the rate of feed digestion as well as to an improvement in the efficiency of nutrient utilization.

ESTIMATING SALIVA PRODUCTION WITH SOLUBLE RUMEN MARKERS: EFFECTS OF INTAKE LEVEL, DIET, AND SLAFRAMINE.

K. Jacques, D.L. Harmon, T.G. Nagaraja, Kansas State University, and W.J.Croom, North Carolina State University.

Two trials with ruminally-cannulated cattle fed bluestem hay-based diets 12 times daily were conducted to study saliva secretion and rumen water balance. Water balance data were determined from simultaneous use of continuously-infused cobalt EDTA and pulse-dosed chromium EDTA with saliva flow estimated by difference of water consumed and ruminal outflow. In trial 1, increasing intake level of either 50% or 90% hay diets increased water intake, saliva flow, ruminal liquid volume, outflow and dilution rate. Increasing the amount of forage from 50% to 90% increased ruminal volume, saliva secretion and ruminal outflow, but did not affect dilution rate or water consumed. Diurnal fluctuations were seen in water intake, saliva flow, dilution rate and ruminal outflow, with higher values seen during day time hours. Increasing intake, decreased ruminal pH and increased total VFA concentration while NH_3-N and molar proportions of acetate, propionate and butyrate were unaffected. Ninety percent forage diets had lower NH_3-N levels and slightly higher ruminal pH, total VFAs and molar proportions of acetate. Slaframine administration at 24µg/kg prompted a 29% increase in saliva flow and was accompanied by higher ruminal liquid volume, dilution and outflow rates. Continuously-infused Co and pulse-dosed Cr provided very similar ruminal outflow rate means in trial 1; however the time required for a continuously-infused marker to equilibrate in the rumen makes this procedure unsuitable for short experiments.

INTERMITTENT FEEDING AND WATERING OF SHEEP

J.M. Asplund, A.P. Mtukuso, C. Cordes and D. Hancock

In arid pasture conditions, animals may graze for long periods of time at a considerable distance from water sources. A study was undertaken to determine the influence on animal performance and nutrient utilization when feed or water were offered only at intervals. Three groups of six sheep each were used in a metabolism experiment. Treatments were: 1) feed and water; 2) continuous feed, but water only every fourth day and 3) continuous water but feed only every fourth day. In experiment 1, the diet was Caucasion Bluestem hay of medium quality and in experiment 2, the diet was medium quality alfalfa hay. The hay was offered free choice to groups 1 and 2 and was offered free choice for 24 hours to group 3 and then withdrawn for 3 days. The animals were kept in metabolism stalls and feed and water consumption measured for a collection period of 12 days. Feces and urine were collected daily. Animals were weighed after an overnight fast at the beginning of the experiment and after an overnight fast following 3 days of recovery on full feed and water at the end.

There was little influence of intermittent water on feed intake. However, when feed was given only every fourth day, the animals did not even consume as much in their one meal as others did when receiving feed and water every day. This suggests that food intake is influenced more by factors immediate to the eating process than by long-term nutrient deprivation. On the other hand, when offered water at wide intervals, the sheep drank much more than the daily intake of those watered daily. Weight gains were not very meaningful because of the short feeding periods and the great impact of gut fill, but they were not reduced by intermittent watering but were obviously lower with intermittent feeding.

Dry matter digestibility increased slightly as total food intake decreased for Bluestem, but decreased in sheep receiving alfalfa intermittently. Nitrogen balance was greatly reduced in the sheep fed at intervals but was higher in those sheep receiving intermittent water. Rumen liquid volume increased throughout the feeding period for the sheep receiving intermittent water, but decreased in those receiving intermittent feed.

From these data, it seems apparent that sheep can be managed with widely separated drinking opportunities without injury to performance but that failure to provide feed daily cannot be compensated for by the sheep and results in substantial losses of performance.

Effect of rate of gain and end weight on visceral organ mass.

G. A. Varga, USDA, Ruminant Nutrition Laboratory, Beltsville, MD 20705

The objective of this experiment was to determine the effect of rate of gain and end weight on visceral organ mass after maintenance restriction. Twenty Angus x Hereford steers (weaned at 130 kg) were used in a completely randomized design with a 2 x 2 factorial arrangement of treatments consisting of .5 (R1) and 1.0 (R2) kg daily gain and end weights of 260 (W1) and 320 (W2) kg. All steers were fed to gain .75 kg/d until they reached 200 kg at which time they were allocated to treatments. Steers were fed twice daily a diet (14.3% crude protein, 2.71 Mcal ME/kg) consisting of 40% chopped alfalfa hay, 50% cracked corn, 2.6% soybean meal, 5% molasses and 2.4% vitamins and minerals. After steers reached the appropriate end weight they were restricted to a maintenance intake (tissue energy = 0) for six weeks. Steers were then fasted for 96h, and fasting heat production measured using indirect calorimetry. The animals were slaughtered immediately after calorimetry measurement and weights of rumen, abomasum, cecum, omasum, small and large intestine, liver, kidneys, heart, lungs, spleen and omental fat were recorded.

Actual rates of gain achieved were .54 and .94 kg/d ($P<.01$, SE = .062) for R1 and R2, respectively. No effect of previous nutrition or end weight were observed for kg of blood, heart, kidney, lungs, rumen, abomasum, small intestine and large intestine. A weight effect was observed for the amount of hide :20.6 vs 26.4 kg ($P<.01$, SE = 1.55), liver was 2.5 vs 3.1 kg ($P<.01$, SE = .15) and omental fat was 7.4 vs 10.7 kg ($P<.01$, SE = .99) for W1 and W2, respectively. Steers had a greater spleen weight ($P<.01$) at W2 than W1 however, on R1 spleen weight decreased while during R2 spleen weight increased (rate x weight, ($P<.01$). Cecal weight was lower at the greater end weight (W2), .62 vs .31 kg ($P<.05$, SE=.12), but was lower ($P<.01$) for R1 compared to R2 (.26 vs .67, $P<.01$). This may suggest that hind gut fermentation plays a greater role in the young animal, but proportionally the cecum decreases as the animal grows. More importantly, the effect of rate of gain is still evident after six weeks of restriction to maintenance intake. A similar significant trend was observed for the omasum however, its weight decreased as rate of gain increased. This indicates that previous nutrition may play an important role in the amount of time feed is held in the omasum as well as effects of overall absorption of nutrients. Lean tissue as a proportion of end body weight decreased ($P<.01$) with increasing body weight and was greater on ($P<.05$) R2 than R1. Fasting heat production (kcal/BW**.75) was 91.7 compared to 83.3 for R1 and R2, respectively ($P<.05$, SE = 2.49). It is concluded that the metabolic activity of various organs, for example kidney and liver, may have changed in oxidative capacity rather than overall mass to affect these changes in fasting heat production due to previous nutrition.

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Effect of retention time on the fermentation of forage fiber and the distribution of nitrogen in the continuous culture of rumen contents.
J. L. Jeraci, C. J. Sniffen and P. J. Van Soest, Dept. of Animal Sci., Cornell University, Ithaca, NY 14853

In this experiment the High Fiber Chemostat (HIFIC) system was used in the cascade mode with duplicate units. Each unit included two vessels (feeding vessels), that delivered the feed in a slurry to the third vessel (fermentation vessel) which contained the rumen microbes and a fourth vessel collected the overflow. Equal quantities of medium and timothy hay were used in all incubations. The model developed by Fadel (1984), was used to determine initial dosing and subsequent dosing of timothy hay (8%CP, 73%NDF on a dry matter basis). Rumen contents (250 ml of liquid and approximately 2 g of DM) were added to duplicate fermentation vessels which contained medium and timothy hay. For the first 24 hr the fermentation vessels were treated as a batch incubation. Then the inflow pump heads were engaged, which started the continuous flow of timothy hay slurry to the fermentation vessels. This standardization of rumen inocula occured before each of the incubations with 4, 8, 16, 24, 32 and 38 hr retention times (RT). After four fermentation vessel volumes were collected as overflow, the contents of the fermentation vessels were collected, processed and analyzed. The whole slurry was filtered through a 37µ Nitex menbrane to obtain solid and liquid phases.

In the incubations with 4, 8, 16, 24, 32 and 38 hr RT, the g of timothy hay NDF organic matter (OM) in/hr was 3.1, 1.6, .78, .52, .39 and .33 respectively. Although the 38 hr RT had the maximum percentage of NDF OM fermented (60%) for an incubation, the rate of NDF OM fermented was the lowest (.2g/hr). The incubation with the 8 hr RT had the maximum rate of NDF OM fermented (.4g/hr). Lineweaver-Burk plots were not linear and multiple enzyme-substrate reaction rates were detected in both Hanes-Woolf and Woolf-Augustinsson-Hofstee plots for NDF, hemicellulose and cellulose. The multiple enzyme-substrate reaction rates of hemicellulose and cellulose were dramatically different.

Nitrogen distribution profiles were different for the solid and liquid phases. The microbial-N in the liquid was very sensitive to the different RT, while the microbial-N in the solid was relatively insensitive to the different RT. The maximum rate of N fermented occured in the incubation with the 4 hr RT, while maximum rate of NDF OM fermented occured in the incubation with the 8 hr RT.

These data suggest: (1) that single enzyme-substrate reaction rate models can not be used to estimate the fermentation kinetics for timothy hay NDF, hemicellulose and cellulose, (2) that the distribution of N in the solid and liquid were different and (3) that the maximum rates of N and carbohydrate fermentation are closely associated with each other.

Fadel, J.G., 1984. Ph.D. Thesis, Cornell University, Ithaca, NY

Comparison of One and Two Compartment Models for Prediction of Fecal Output of Cattle Grazing Wheat Pasture. J. W. Oltjen, G. W. Horn and T. L. Mader, Animal Science Department, Oklahoma State University, Stillwater, OK 74078

External markers may be used to estimate rate of passage, fecal output, and subsequently forage intake of grazing ruminants. However, controversy has arisen over the choice of model used to make these estimates. Both the one and two compartment models with time delays have been used with varying degrees of success at fitting marker data and identifying model parameters. The objective of this research was to compare the one and two compartment model estimates of total fecal output with observed values. Three groups of three steers (291 kg body weight) were assigned three supplement treatments in three periods in a 3X3 Latin square design. Supplement treatments were ad libitum access to wheat straw and wheat pasture, ad libitum access to sorghum-sudan hay and wheat pasture, and ad libitum access to only wheat pasture. The three time periods were fall grazing before winter wheat dormancy (December through mid-January), winter dormancy (mid-January through February), and lush spring growth (March). Each period consisted of 11 day adaptation and 5 day fecal collection phases. At the beginning of the collection phase, steers were dosed with 195 g wheat forage dry matter labelled with 1.6 g Yb and feces were sampled 6, 10, 14, 24, 30, 36, 48, 58, 72, 82, 96, 106 and 120 hours later. One and two compartment models (Ellis et al. 1979. Fed. Proc. 38:2702) were fit to the fecal Yb concentration data using a modified Marquardt method to estimate rate constants and lag time. Average mean square error was 7531 and 2148 (mg Yb/kg fecal dry matter)^2 for the one and two compartment models, respectively. Simple correlation coefficients (r) for predicted and actual fecal outputs were .72 and .84 for the 27 one and two compartment model observations, respectively. The mean and standard deviation of residual (predicted-observed) fecal output was .003 and .383 kg for the one compartment model and -.159 and .230 kg for the two compartment models, respectively. The residuals were not related to either supplement treatment, period or steer weight for either model ($P>.15$). Residual fecal output was related to mean square error, $r=.72$, for the one compartment model ($P<.001$) but not for the two compartment model ($r=-.22$, $P>.25$). Absolute fecal output was not related to mean square error for the two compartment model ($r=.07$). In summary, the data from this study show that use of either model has limitations. Overall, fit of the marker data was improved by using the two compartment model. Fecal outputs predicted for the two compartment model were generally more precise but less accurate, due to a tendency for underprediction. In cases where the one compartment model fit the marker data poorly, fecal output was overestimated. No systematic effect due to lack of fit was observed for the two compartment model. Also, no loss of precision for estimates of fecal output was observed with increasing lack of fit of the two compartment model.

Ruminal retention time and fill in dairy cows: Effects of level of feed intake, forage physical form and forage fiber content. R.D. Shaver, L.D. Satter and N.A. Jorgensen, USDA, ARS, U.S. Dairy Forage Research Center, University of Wisconsin, Madison 53706

Rumen fill can physically limit intake in dairy cows fed high forage diets. Forage particle size and level of feed consumption affect ruminal retention time and fill, but these factors have not been adequately evaluated in diets containing high quality forage. Data on effects of forage fiber content on rumen fill in high producing dairy cows is limited. In Trial 1, six Holstein cows were fed prebloom alfalfa hay in long (LH), chopped (CH), and pelleted (PH) form in a replicated 3x3 Latin Square design conducted in early and mid-lactation and during the dry period to attain high (H), medium (M) and low (L) levels of feed intake. In Trial 2, pre- (AE), mid- (AM), and full- (AL) bloom alfalfa hay, bromegrass (BR) hay, and corn silage (CS) were fed to early lactation Holsteins in a 5x5 Latin Square design. All diets were formulated to 17% crude protein (CP) and contained forage: grain in a 60:40 ratio (DM basis). Rumen fill was determined by manual emptying. Chromium - EDTA and ytterbium were used as liquid and solids passage markers. Ruminal digestion kinetics were by the *in situ* dacron bag method. Forage CP, neutral (NDF) and acid (ADF) detergent fiber were: Trial 1 - 22.4, 41.3, 30.9; Trial 2 - AE) 23.2, 42.2, 32.6; AM) 17.8, 54.3, 43.7; AL) 16.7, 56.2, 45.8; BR) 10.5, 71.8, 43.3; CS) 6.5, 44.6, 24.5 Results are summarized below:

	Trial 1						Trial 2				
	Level of Intake			Treatment			Treatment				
Item	H	M	L	LH	CH	PH	AE	AM	AL	BR	CS
DM intake,											
% body weight	3.75	2.93	1.95	2.89	2.90	2.84	4.03	3.49	3.43	3.08	4.04
kg/d	24.3	20.2	14.5	19.8	20.0	19.2	23.3	20.2	20.0	17.9	23.9
Milk production, kg/d	34.6	21.5	--	27.4	28.0	28.9	38.0	32.6	32.1	29.7	36.5
Ruminal fill											
Wet, kg	74.6	66.2	65.9	74.1	73.5	59.1	67.2	76.0	74.0	90.0	67.3
DM, kg	10.1	9.9	8.1	9.5	9.6	9.0	9.3	10.5	10.4	13.0	11.0
kg/kg DM intake	.42	.49	.56	.48	.48	.47	.40	.52	.52	.73	.46
Ruminal retention time, ($\bar{1}/K_1$)											
YB (forage), h	15.6	21.1	26.4	21.3	20.0	21.8	18.9	21.4	20.8	25.5	19.6
Cr (liquid), h	9.8	9.9	12.4	10.7	10.1	11.4	7.4	8.1	8.2	9.5	9.3
In situ NDF digestion											
Potentially digested, %	52.3	49.3	54.8	54.7	53.2	48.5	58.4	44.1	43.3	61.7	42.4
Rate (k), h^{-1}	.070	.065	.067	.074	.075	.052	.093	.073	.075	.043	.044

Forage physical form has little effect on ruminal retention time and fill when low fiber forage is fed. Low rumen fills per unit intake for low fiber forages suggests that the point of intake limitation due to gut fill is dependent on forage quality as well as energy demand of the animal.

A Survey of Particle Size Analysis Methods. M. R. MURPHY, Dept. of Animal Sci., University of Illinois, Urbana, IL 61801

Most ruminant nutritionists agree that the physical form of a diet is an important determinant of its nutritive value. Digestion is affected because smaller particles have a relatively larger surface area for microbial attachment. Passage from the rumen, which determines to a large extent both the amount and pattern of nutrients eventually absorbed by the animal, is also affected by particle size. Although others are being developed, many methods are now available to estimate particle size distributions of feedstuffs. A nest of sieves, arranged so material falls from sieves with larger pore sizes to those with smaller pores, is commonly used to fractionate samples and the portions recovered on particular screens are reported. This experiment was designed to compare various sieving methods based on analyses of particle size distributions of a few feedstuffs. Duplicate samples (approximately 60g each) of alfalfa haylage; corn silage; and a ground, corn based, grain mix were sent to cooperating laboratories that have published particle size analysis data.

Results were received which represented a wide range of particle size methods. Data were well fit by the lognormal distribution. Mean particle size of each feed varied considerably depending on method of analysis. In some cases differences can be easily explained. Neutral detergent fiber (Lab A) of the grain mix was larger than the untreated sample. Corn kernels were also removed from the corn silage before NDF was prepared which decreased the mean particle size for this sample compared to other methods. Labs B and C used a Fritsch Analysette sieving apparatus. Although this equipment has been used for particle size analyses of digesta samples, forage material was retained by screens with large pores which inflated the mean particle size of alfalfa haylage and corn silage compared to other methods. The $\log_{10}$ standard deviations of the distributions were larger, indicating material was more spread out, for wet sieving methods. Relative ranking of feedstuffs by mean particle size suggested similar results were obtained across labs A, H, J, M and N.

	Alfalfa Haylage[b]			Corn Silage			Grain Mix			
Lab/Method[a]	r^2	$\bar{X}$	SD	r^2	$\bar{X}$	SD	r^2	$\bar{X}$	SD	Ratio[c]
A Dry, 3-5 NDF	.93	1,980	.50	.99	2,610	.48	.97	1,250	.42	.8:1.0: .5
B Wet, 2-3 DM	.93	12,340	.96	.78	6,520	.89	.89	1,060	.77	1.0: .5: .1
C Wet, 4-5	.97	21,820	1.01	.99	13,060	.81	ND	ND	ND	1.0: .6: ND
H Dry, All	.98	2,840	.46	.92	3,370	.38	.94	880	.44	.8:1.0: .3
J Wet, 10 DM	.99	4,780	.78	.97	6,010	.74	.91	770	.49	.8:1.0: .1
M Dry, 15-40	.98	2,260	.33	.99	4,060	.42	.99	1,080	.44	.6:1.0: .3
N Wet, 10-20	.96	1,860	.62	.87	4,330	.65	.93	790	.57	.4:1.0: .2

[a] Dry or wet sieved, sample size (g) and treatment if applicable. Neutral detergent fiber = NDF, dry matter = DM.

[b] For each feedstuff r^2 applies to the line fitting a lognormal distribution to the data, $\bar{X}$ is the mean particle size in μm, and SD is the $\log_{10}$ standard deviation of the distribution. Not determined = ND.

[c] Ratio is the relative mean particle size, alfalfa haylage:corn silage:grain mix. The feed having the largest mean particle size was set equal to one.

Variance associated with using ytterbium as a digestibility marker. J.M. Lopez-Guisa, W.F. Nelson, and L.D. Satter. U.S. Dairy Forage Research Center, University of Wisconsin, Madison.

The estimation of digestibility from a particular feedstuff is commonly used as general index of its nutritive value. The standard digestibility trail involves accurate records of feed consumption and fecal output. To obtain the latter, close confinement in digestion crates or use of collection bags is required. This is not possible for all animal experiments, due to the lack of facilities, inability of the animal to cope with the stress of close confinement, or insufficient labor to properly carry out digestion trails involving large numbers of animals, particularly cattle. Indigestible markers have been used to determine digestible coefficients. However, little effort has been made to quantify the variance associated with the technique. The objective of this study was to quantify the variance associated with using ytterbium as a marker for determining digestibility in cattle.

In the first study ytterbium chloride was sprayed onto the feed and the concentration of ytterbium in the final diet was 20 mg yb/kg diet dry matter. Forty-four Holstein heifers were divided into four groups of eleven animals each, and fed test diets. Fecal samples were obtained from the rectum at 0600, 0800, 1100, 1300, 1500, 1700, 2100 and 2300 hours. In the second study ytterbium chloride was sprayed onto the feed and the concentration of ytterbium in the final diet was 23 mg yb/kg diet dry matter. Fifty-five lactating Holstein cows were divided into three groups of 18, 18 and 19 animals, respectively. Fecal samples were obtained from the rectum at 0100, 0300, 0700, 1000, 1100, 1600 and 1700 hours. Samples from both studies, following drying and grinding, were wet ashed. Ytterbium content was determined by emmission spectrophotometry.

Results from each experiment were considered as a separate population, and variance between animals within sampling times was measured as well as variance between sampling times within animals. Variance between cows was larger than variance between heifers within times. The numbers of animals required to detect a specified difference with a given probablity were calculated based on the variance in each population (Table 1).

To conclude, ytterbium is a good digestibility marker. It can be accurately determined by several methods. More animals must be used to obtain the same accuracy in measuring digestibility coefficients with a marker technique compared to total fecal collection, but often the case of using a marker technique offsets the increased number of animals required. More importantly, the animal stress associated with some total collection studies can preclude making digestibility measurements at normal level of feed intake.

Table 1. Number of animals required for detecting a given difference in digestibility with a probability of .9.

True difference (As percent of Digestibility)	Number of Animals		
	Heifers	Cows	Sheep (a)
1.0	64	228	28
1.5	29	101	14
2.0	16	57	8
2.5	10	36	6
5.0	3	9	3

(a)From total collection studies. Raymond, W.F., Co. E. Harris and V.G. Harker, 1953. J. Brit. Grassland Soc. 8:301

Effect of Feeding Frequency on Forage Fiber and Nitrogen Utilization in Sheep.
M. D. HOWARD, L. D. BUNTING, R. B. MUNTIFERING, K. A. DAWSON and J. A. BOLING, Department of Animal Sciences, University of Kentucky, Lexington, KY 40546-0215.

Four wether lambs (38 kg) with permanent ruminal and abomasal cannulae were used in a Latin square arrangement of treatments to determine the effect of feeding frequency on forage fiber and nitrogen (N) utilization. Lambs were fed 900 g/d of good quality Kentucky-31 tall fescue hay in equal portions offered 2X, 4X, 8X or 16X daily. Increasing feeding frequency increased ($P<.05$; linear) water consumption by lambs and tended to decrease ruminal fluid NH_3-N concentration. Feeding more frequently than 2X daily increased ($P<.05$; cubic) microbial N flow at the abomasum and tended to increase fecal N excretion. Microbial crude protein (MCP) synthesized per 100 g organic matter (OM) fermented averaged 21 g (corrected for microbial OM) across all treatments, and tended to be more efficient as frequency of feeding increased. Ruminal digestion of acid detergent fiber (ADF) responded in a cubic ($P<.05$) fashion to increasing frequency of feeding, with higher coefficients observed for 2X and 8X than 4X and 16X daily feeding. Total tract digestion of forage cell walls was unaffected by treatment, although increasing feeding frequency tended to increase ruminal escape of potentially digestible fiber (PDF); hemicellulose was more susceptible to ruminal escape than was ADF. Passage of PDF to the lower tract was positively correlated with extent ($r = .42$; $P<.10$) and efficiency ($r = .71$, $P<.05$) of MCP synthesis, indicating that increased microbial protein supply to the lower tract was achieved at the expense of some fermentable energy loss. Daily N retention was unaffected, suggesting that frequent feeding of a good quality forage may only be beneficial when protein supply to the lower tract is more limiting to performance than are other nutrients or energy.

P R O G R A M

XVIII CONFERENCE ON RUMEN FUNCTION

AMERICANA CONGRESS HOTEL, CHICAGO, IL
November 13-14, 1985

PRE-CONFERENCE MIXER - AMERICANA CONGRESS HOTEL
(Uncle Albert's and Music Box Rooms)
Tuesday, November 12 (8:30-10:00 p.m.)

Support for Mixer and for Coffee on Wednesday and Thursday Kindly Supplied by UPJOHN AND COMPANY, Kalamazoo, MI; CHEMICAL DIVISION OF EASTMAN KODAK COMPANY, Kingsport, TN; and PURINA MILLS, INC., St. Louis, MO

WEDNESDAY, November 13, 1985
Windsor Room, Main Floor, Americana Congress Hotel

8:10 -- Opening - Announcements, etc.

Physiopathology Panel - W. M. Wass, Panel Chairman

8:15 -- Changes in rumen pH and electrolyte concentrations as influenced by upper duodenal obstruction. T. Avery, Kansas State University, Manhattan

8:30 -- Efficacy of activated charcoal in the treatment of acute grain overload. W. B. Buck, University of Illinois, Urbana

8:45 -- Effects of aflatoxin on rumen motility. Wm. Cook, University of Illinois, Urbana

9:00 -- Feed aversion induced in cattle by rumen infusion of larkspur extract or lithium chloride. J. D. Olsen and M. H. Ralphs, USDA Poisonous Plant Research Laboratory, Logan UT

9:15 -- Do soluble constituents in silage affect oro-pharyngeal responses in sheep? J. G. Buchanan-Smith, University of Guelph, Guelph, Ontario, Canada

9:30 -- Structure of the activated 3-methylindole metabolite associated with acute lung injury in cattle. J. R. Carlson, Washington State University, Pullman

Agronomic Panel - J. C. Burns, Chairman

9:45 -- Animal and plant productivity as affected by global synchronized annual changes in extractable soil minerals. Charles H. Mullenax, University of Missouri, Columbia

10:00 -- Ionophore effects in spring-calving beef cows grazing tetany-prone tall fescue. J. A. Boling, N. Gay, G. M. Davenport, L. D. Bunting, and K. A. Dawson, University of Kentucky, Lexington

10:15 -- Use of tethered steers for estimating intake of fescue pastures. R. H. Hitchcock, R. B. Muntifering, N. W. Bradley, A. Wahab, P. J. Ballerstedt, C. T. Daugherty, R. B. Razor, and E. M. Smith, Depts. of Animal Science, Agronomy and Engineering, University of Kentucky, Lexington

10:30 -- Efficacy of treating high moisture alfalfa hay with chemical or biological preservatives. M. Saiday, M. J. Arambell and P. V. Fonnesbeck, Dept. of Animal, Dairy and Veterinary Sciences, Utah State University, Logan

10:45 -- Digestion of normal and bmr sorghums. D. E. Akin, L. L. Rigsby, M. E. Snook, D. S. Himmelsback, F. E. Barton, II, W. R. Windham, and W. W. Hanna, Russell Research Center, USDA, ARS, Athens, GA, and Coastal Plains Experiment Station, ARS, Tifton, GA

Agronomic Panel (cont'd.)

11:00 -- Dry matter intake by steers and digestion coefficients of dry matter and cell wall constituents of subtropical grasses with similar NDF concentrations. J. C. Burns, R. D. Mochrie and D. H. Timothy, North Carolina State University, Raleigh

11:15 -- Inhibition of cellulose digestion by esterified cynamic acid. H. G. Jung and T. Sahla, Meat Animal Research Center, USDA, ARS, Clay Center, NE

BREAK -- LUNCH

Microbiology Panel - J. B. Russell, Panel Chairman

1:00 -- Keynote address. R. E. Hungate, Dept. of Bacteriology, University of California, Davis

1:30 -- Comparison of rumen-fistula with stomach-tube collected ruminal fluid inocula in batch culture fermentation. M. L. Ogilvie, J. A. Z. Leedle, R. C. Greening, and D. D. Kratzer, The Upjohn Company, Kalamazoo, MI

1:45 -- Evaluation of an *in vitro* system using a washed rumen bacterial inoculum. J. Argyle and R. B. Hespell, Dept. of Dairy Science, University of Illinois, Urbana

2:00 -- Adaptation of a semicontinuous system to test the effects of chemicals on rumen fermentation. P. F. Machado, P. Kone, and R. M. Cook, Dept. of Animal Science, Michigan State University, East Lansing

2:15 -- Rumen microbial development in early - or conventionally - weaned calves. K. L. Anderson, T. G. Nagaraja, J. L. Morril, and T. B. Avery, Dept. of Animal Science and Industry, Kansas State University, Manhattan

2:30 -- Comparison of fecal bacterial populations of adult and juvenile okapi. H. R. Mansfield and L. Montgomery, Dept. of Animal Science, University of Illinois, Urbana

2:45 -- Phenolic compounds and rumen bacteria. S. Borneman and D. E. Akin, ARS, USDA, Russell Research Center, Athens, GA

3:00 -- Some new rumen bacterial isolates capable of phenolic conversions. L. R. Krumholz and M. P. Bryant, Dept. of Dairy Science, University of Illinois, Urbana

3:15 -- Effect of pentachlorophenol (PCP) selectivity on rumen bacterial species. M. T. Yokoyama and K. A. Johnson, Dept. of Animal Science, Michigan State University, East Lansing

3:30 -- Effect of 3-phenylpropanoic acid on the growth and cellulolytic activity of selected ruminal bacteria. R. J. Stack and M. A. Cotta, Northern Regional Research Center, ARS, USDA, Peoria, IL

Microbiology Panel (cont'd)

3:45 -- Factors affecting the release of activity from radioactive cellulose by rumen microorganisms. C. S. Stewart and S. H. Duncan, The Rowett Research Institute, Aberdeen, Scotland

4:00 -- The effect of treatment of dietary wheat straw on microbial populations of the sheep rumen. L. Montgomery, M. S. Zino, and H. R. Mansfield, Dept. of Animal Science, University of Illinois, Urbana

4:15 -- Magnesium bioassay by rumen bacteria. K. M. Edlin, R. E. Tucker, K. A. Dawson, R. B. Muntifering, and G. E. Mitchell, Jr., Dept. of Animal Science, University of Kentucky, Lexington

4:30 -- Microbial ecology of proteolysis in the rumen. R. J. Wallace, The Rowett Research Institute, Aberdeen, Scotland

4:45 -- Protein and amino acid degradation by rumen microbial enzymes. S. Mahadevan, J. D. Erfle, F. D. Sauer, and R. Gopitnath, Animal Research Center, Agriculture Canada, Ottawa

5:00 -- The distribution of ionophore-resistance in bacterial groups from the rumen of calves fed lasalocid and/or potassium supplements. K. A. Dawson, W. S. Cain, and J. A. Boling, University of Kentucky, Lexington

5:15 -- Lactate efflux from Selenomonas ruminantium. R. J. Wallace and J. D. Robertson, The Rowett Research Institute, Aberdeen, Scotland

5:30 -- Recent advances in Bacteroides genetics. A. Salyers, Dept. of Microbiology, University of Illinois, Urbana

5:45 -- Rumen bacterial heat production in continuous culture. J. B. Russell, ARS, USDA and Dept. of Animal Science, Cornell University, Ithaca, NY

THURSDAY, November 14, 1985
Windsor Room, Americana Congress Hotel

Nutrition Panel - J. T. Huber, Panel Chairman

8:00 -- Effect of supplemental Saccharomyces cerevisiae or Aspergillus oryzae on rumen fermentation. M. J. Arambel and R. D. Wiedmeier, Utah State University, Logan

8:15 -- Effects of nonstructural carbohydrate and protein source on ruminal bacterial protein synthesis in continuous culture. M. D. Stern, M. J. Allen, P. M. Windschitl and W. J. Wong, University of Minnesota, St. Paul

8:30 -- Effects of cobalt supplementation on carbohydrate and nitrogen utilization by ruminal bacteria in continuous culture. M. J. Allen and M. D. Stern, University of Minnesota, St. Paul

Nutrition Panel (cont'd)

8:45 -- Lactational and systemic responses of high producing dairy cows to the addition of protected methionine in soybean meal diets. D. J. Illg, J. L. Sommerfeldt, and D. J. Schingoethe, South Dakota State University, Brookings

9:00 -- Influence of bacterial nitrogen contamination on *in situ* nitrogen digestion of forages stored at different dry matters. J. E. Nocek and A. L. Grant, Agway, Inc., Syracuse, NY

9:15 -- Concentration of flow of peptides from the rumen of cattle fed different amounts and types of protein. C. J. Sniffen, G. Chen, and J. B. Russell, Cornell University, Ithaca, NY

9:30 -- Effect of dietary protein level on nitrogen metabolism in sheep: Studies using ^{15}N-nitrogen. L. D. Bunting, J. A. Boling, C. T. MacKown, and R. B. Muntifering, Dept. of Animal Sciences, University of Kentucky, Lexington

9:45 -- Ammonia treatment of high-tannin peanut skins in beef cattle diets. G. M. Hill, University of Georgia, Tifton

10:00 -- Utilization of nitrogen in ammonia treated straws. J. R. Males and D. DeAvila, Washington State University, Pullman

10:15 -- Influence of rumen ammonia concentration in *in situ* fractional degradation rates of barley and corn. J. Odle, D. M. Schaefer, and J. W. Costerton, University of Wisconsin-Madison and University of Calgary

10:30 -- Effect of diet concentrate level and $NaHCO_3$ on site and extent of forage fiber digestion in the gastrointestinal tract of wethers. K. J. Wedekind and R. B. Muntifering, University of Kentucky, Lexington

10:45 -- Mineral absorption and balance in ruminants fed monensin. L. W. Greene, G. T. Schelling, and F. M. Byers, Texas A&M University, College Station

11:00 -- Relationship of rate of dissolution of magnesium oxide to excretion of magnesium in cattle. L. J. Wheeler, C. H Noller, and J. A. Patterson, Purdue University, West Lafayette, IN

11:15 -- Predicting B vitamin supply to the small intestine of cattle. R. A. Zinn, F. N. Owens, R. L. Stuart, J. R. Dunbar, and B. B. Norman, Oklahoma State University, Stillwater

11:30 -- BREAK

12:30 -- Protein and energy utilization by goats. N. Singh, National Dairy Research Institute, Karnal (Haryana), India

12:45 -- *In situ* evaluation of lipid effects on soybean protein disappearance. G. M. Davenport, J. A. Boling, L. D. Bunting, and N. Gay, University of Kentucky, Lexington

Nutrition Panel (cont'd)

1:00 -- Effects of isoacids on rumen fermentation and plasma hormone levels in sheep. A. V. Brondani and R. M. Cook, Michigan State University, East Lansing

1:15 -- Estimating saliva production using rumen water flow: effects of intake, diet and slaframine. K. Jacques, D. L. Harmon, T. G. Nagaraja, and W. J. Croom, Jr., Kansas State University, Manhattan, and North Carolina State University, Raleigh

1:30 -- The influence of intermittent feeding and watering on nutrient utilization in sheep. J. M. Asplund, A. P. Mtukuso, D. Hancock, and C. Cordes, University of Missouri, Columbia

1:45 -- Rate of gain and end weight effects on visceral organ mass and gut contents of steers. G. Varga, The Pennsylvania State University, University Park

2:00 -- Effect of retention time on the digestion of forage fiber and the distribution of nitrogen in the continuous culture of rumen contents. J. L. Jeraci, C. J. Sniffen, and P. J. Van Soest, Dept. of Animal Science, Cornell University, Ithaca, NY

2:15 -- Comparison of one and two compartment models for prediction of fecal output of grazing cattle. J. W. Oltjen and G. Horn, Oklahoma State University, Stillwater

2:30 -- Ruminal retention time and fill in dairy cows: Effects of level of feed intake, forage physical form and forage fiber content. R. D. Shaver, L. D. Satter, and N. A. Jorgenson, USDA, ARS, U.S. Dairy Forage Research Center, University of Wisconsin, Madison

2:45 -- A survey of particle size analysis methods. M. R. Murphy, University of Illinois, Urbana

3:00 -- Variance associated with using ytterbium as a digestibility marker. J. Lopez-Guisa, W. F. Nelson, and L. D. Satter, U. S. Dairy Forage Research Center, University of Wisconsin, Madison

3:15 -- Effect of feeding frequency on forage fiber and nitrogen utilization in sheep. M. D. Howard, L. D. Bunting, R. B. Muntifering, K. A. Dawson, and J. A. Boling, Dept. of Animal Sciences, University of Kentucky, Lexington