Estimation of the energy value of a ration is fundamental for the determination of the quantity required to meet the energy requirement of the animal. Net Energy is the best estimate of the energy value of a feed/ration, but is difficult, time consuming and costly to determine. In addition, it is virtually impossible to measure the energy value of a single feedstuff fed to a representative animal because few, if any, feedstuffs contain the appropriate balance of nutrients required by the target animal. In practice, estimated net energy value of individual feedstuffs used in ration formulation have been derived from equations relating net energy value to some more easily determined characteristic of a feedstuff, typically some measure of digestibility such as Total Digestible Nutrients (TDN). This method is reasonably accurate as long as the TDN value used is appropriate for the target animal. For example, it is well established that the TDN value of a ration fed to a lactating dairy cow at a daily intake required to support lactation is significantly lower than the TDN value of the same ration fed to the same cow at a maintenance level of intake when the cow is simply fed hay. Level of intake may affect the energy value of a feed/ration, but is difficult, time consuming and costly to determine. The database used to develop the passage rate (kp) equations of the 2001 Dairy NRC was inverted; it should be kp dry forage $= 3.362 + 0.479 \text{ DMIPBW} - 0.017 \text{ NDFF} + 0.007 \text{ ConcpDM}$ (n=399); kp wet forage $= 3.374 + 1.123 \text{ DMI}_{pBW} - 0.016 \text{ ConcpDM}$ (n=264). We conclude these equations were: kp dry forage $= 2.819 + 0.684 \text{ DMIPBW}$; kp for dry forage (0.092) and wet forage (0.019) in the prediction of kp for dry forage was 0.863. Accuracy was improved when only one of several factors which can depress the TDN value of a ration fed at production levels of intake. Protein quantity/quality which is adequate to support maximal digestibility in an animal at maintenance may significantly depress TDN value when protein is limiting for lactation. TDN measured using sheep may be appropriate for the estimation of the energy value of feedstuffs for cattle where appropriate equations are available. Variation in digestibility of feed is the main source of variation in energy value of feed.

**Key Words:** Net Energy, Digestibility, TDN


The improvement in Feed Efficiency (FE; Milk/Dry Matter Intake) by dairy cows can have a dramatic impact on the profitability of the dairy operation. This study was conducted to evaluate the range in FE across several farms and to determine what factors may affect FE. Total mixed rations (TMR) and fecal samples were collected from six dairy farms that were feeding a total mixed ration, along with measurements of milk production, milk composition, and dry matter intake (DMI). The only one of several factors which can be expected to affect kp dry forage at production levels of intake. Protein quantity/quality which is adequate to support maximal digestibility in an animal at maintenance may significantly depress TDN value when protein is limiting for lactation. TDN measured using sheep may be appropriate for the estimation of the energy value of feedstuffs for cattle where appropriate equations are available. Variation in digestibility of feed is the main source of variation in energy value of feed.

**Key Words:** Feed Efficiency, Digestibility, Forage Quality

### 934 Predicting feed passage rate in dairy cattle. S. Seo¹, L. Tedeschi¹, C. Schwab², and D. G. Fox¹.¹ Cornell University, Ithaca, NY, ²University of New Hampshire, Durham.

The database used to develop the passage rate (kp) equations of the 2001 Dairy NRC was used to perform a sensitivity analysis on the variables used to derive the equations and to investigate the sensitivity of the equations to changes in MP supply and allowable milk production using a Monte Carlo technique. Three equations were developed by the 2001 Dairy NRC to predict kp for dry forage, wet forage, and concentrate using a meta-analysis technique (trial as a random effect). The database was comprised of studies that used rare earth markers. Outliers were identified by acceptance criteria defined a priori or the difference in fit statistic (DFFITS) value. We found the sign of the regression coefficient of ConcpDM in the equation for kp dry forage in 2001 Dairy NRC was inverted; it should be kp dry forage $= 3.362 + 0.479 \text{ DMIPBW}$; kp wet forage $= 2.819 + 0.684 \text{ DMIPBW}$; kp for dry forage (0.092) and wet forage (0.019) in the prediction of kp for dry forage was 0.863. Accuracy was improved when only one of several factors which can be expected to affect kp dry forage at production levels of intake. Protein quantity/quality which is adequate to support maximal digestibility in an animal at maintenance may significantly depress TDN value when protein is limiting for lactation. TDN measured using sheep may be appropriate for the estimation of the energy value of feedstuffs for cattle where appropriate equations are available. Variation in digestibility of feed is the main source of variation in energy value of feed.

**Key Words:** Feed Efficiency, Digestibility, Ruminal pH

### 935 Effect of peNDF and starch source on digestibility and ruminal pH and turnover in dairy cows. P. Berzagli²,³ and D. R. Mertens¹.¹ University of Padova, Italy, ³ARS-US Dairy Forage Research Center, Madison, WI.

The effects of ration physiologically effective NDF (peNDF) and starch source on ruminal characteristics and digestibility were investigated. A negative control (NC) diet was formulated to induce milk fat depression, which contained 19% peNDF using finely chopped (TLC = 6.4 mm) corn silage as the main fiber source. Three diets were formulated to increase peNDF to 22% by adding about 9.5% finely chopped corn silage (CS), 12.2% chopped alfalfa hay (AH), or 6.7% chopped grass hay (GH) to NC. Diets for the four fiber sources were formulated with dry ground corn (DGC) or finely ground high moisture corn (HMC) to obtain eight diets that varied in starch source and peNDF source and concentration. Twenty-four cows were blocked for milk production and half were assigned to either DGC or HMC diets in replicated 4x4 Latin squares with 21d periods. One Latin square for starch source contained ruminally fistulated cows. In the cannulated cows ruminal pH was measured for one day every three hours and rumen contents were manually evacuated before and after feeding and separated into solids and liquids. Fecal samples were obtained during the last week of each period. In vitro digestibility of NDFs, ruminal contents and feces was determined by 240-h in situ incubation in all cows in the period following their respective collections. Mixed-model ANOVA indicated that NC and CS had lower (P<0.05) ruminal pH at 3-h post feeding, but similar average (24 h) ruminal pH across diets. Rumen pool of DM and indigestible NDF (INDF) was not affected (P>0.05) by diet and starch source. However, turnover rate of INDF was increased (P<0.05) by the addition of AH and GH to the NC diet. Apparent DM digestibility (DMD) was not affected by starch source, but was highest for NC diet and lowest (P<0.01) in AH and GH. A positive relationship (r²=0.54; P<0.01) between retention time and DMD partially explained the differences in digestibility. In conclusion, dietary peNDF altered ruminal pH and affected DMD possibly by changes in retention time and associative effects.

**Key Words:** Physically Effective Fiber, Digestibility, Ruminal pH

### Key Words:
- Net Energy
- Digestibility
- TDN
936 In situ estimation of dry matter digestibility and degradable intake protein to evaluate the effects of corn processing method and length of ensiling. J. R. Benton*, T. J. Klopfenstein, and G. E. Erickson, University of Nebraska, Lincoln.

Three ruminally cannulated steers were used to evaluate the effects of corn processing method and length of ensiling on dry matter digestibility (ISDMD) and degradable intake protein (DIP). Corn processing consisted of dry-rolled (DRC), high-moisture at 24% (24HMC) or 30% (30HMC) moisture, and reconstituted corn at 28% (28RECON) or 35% (35RECON) moisture, all of the same hybrid. All corn (except DRC) was ensiled for at least 298 d, and sampled every 28 d. Corn samples were incubated in situ for 0, 22, 30, and 72 h and ISDMD (%) and DIP (%) of CP were calculated. Values (22 h) were regressed over ensiling days. The intercept represents changes in ISDMD or DIP during the first 28 d of ensiling where the greatest changes occurred, with the greatest increase for 35RECON followed by 30HMC and then 28RECON. The slope represents changes in ISDMD or DIP over time of ensiling after 28 d. The slope of reconstituted corn (RECON) were greater than high-moisture corn (HMC) because RECON had a greater increase in total ISDMD and DIP compared to HMC. The slope of 24HMC was not different from 30HMC for ISDMD, while the slope of 24HMC was greater than 30HMC for DIP. The slope of 28RECON was greater than 35RECON for ISDMD and DIP. When moisture was increased for HMC (from 24 to 30%) and RECON (from 28 to 35%), total ISDMD and DIP increased, and both HMC and RECON had increased total ISDMD and DIP compared to DRC. Results suggest that as moisture and length of fermentation increase, ISDMD and DIP are increased.

<table>
<thead>
<tr>
<th>Corn</th>
<th>ISDMD (%)</th>
<th>DIP (%) of CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>24HMC</td>
<td>38.0</td>
<td>77.5 (1.2)</td>
</tr>
<tr>
<td>30HMC</td>
<td>45.4</td>
<td>61.3 (1.0)</td>
</tr>
<tr>
<td>28RECON</td>
<td>29.0</td>
<td>68.1 (1.0)</td>
</tr>
<tr>
<td>35RECON</td>
<td>29.0</td>
<td>68.1 (1.0)</td>
</tr>
<tr>
<td>DRC</td>
<td>29.0</td>
<td>68.1 (1.0)</td>
</tr>
</tbody>
</table>

Values in parenthesis are standard errors.

Key Words: Grain Processing, In Situ, Protein Digestion

937 Effects of nonfiber carbohydrate source and protein degradability on ruminal protein fractions and NDF disappearance. M. B. Hall* and C. C. Larson, Department of Animal Sciences, University of Florida, Gainesville.

Effects of nonfiber carbohydrate source (NFC) and protein degradability (RUP) on concentrations (mM) of ammonia (NH3), amino acid (AA), and branch chain VFA (BCVFA) in ruminal fluid, and on in situ disappearance of NDF from sorghum silage were evaluated using 6 ruminally cannulated Holstein cattle in a three period (21 d) partially balanced incomplete latin square design with a 3x2 factorial arrangement of treatments. Dietary treatments included three NFC sources (ground corn=starch=ST; molasses+sucrose=sugar=SU; and citrus pulp=soluble fiber+sugar=SF) and two concentrations of ruminal protein digestion or use differed by NFC source with ST greater than SU+SF, and SF tended to be greater than SU. (P<0.05).

Key Words: Dairy Cattle, Starch, Digestion


In ruminants, propionic acid and glucose are the main glycogenic precursors. Thus, the supply of glycogenic precursors from starch is related to its site of digestion. In this study the site of digestion of starch from wheat, corn, and potato was evaluated in dairy cows. A Latin square design experiment was performed involving four lactating dairy cows each fitted with a rumen cannula and T-piece cannul in the distal duodenum and terminal ileum. Each cow received either a starch-free diet, containing 43 %DM grass silage, 11 %DM ensiled sugar beet pulp and 46 %DM of a starch free concentrate mixture with 70 % dried sugar beet pulp (DBBP) or diets in which DBBP had been replaced by either wheat (W), corn (C) or potato (P) starch. Diets were fed during periods of four weeks, faecal and digesta collections were performed in the third and fourth week of each period, respectively. The glycogenic nutrient supply for each diet was estimated on the basis of the amounts of OM digested in rumen and large intestine, patterns of VFA concentrations in the rumen and the amount of starch digested in the small intestine. Significant was declared at P<0.05. Starch intake was 0.31°, 3.47°, 3.90°, and 3.69 kg/day for control diet, and diets with WS, CS and PS, respectively. The rumen was the main site of digestion for starches from all origins and was estimated at 90°, 75°, and 84° % of intake of WS, CS and PS, respectively. In the small intestine, 70% of rumen escaped WS was digested compared to 65% for CS, but this difference was not significant. We observed no disappearance of PS in the small intestine. Almost all starch entering the large intestine was digested, resulting in a faecal starch output of less than 0.10 kg/d. Concentrations of ruminal VFA were similar amongst treatments. The proportion of propionate in rumen fluid differed significantly between the WS diet (21 mol%) and the PS diet (18 mol%). The highest supply of glycogenic nutrients was calculated for the CS diet (0.8 moles per kg ingested OM). According to our calculations, the PS diet yielded the lowest supply of glycogenic nutrients (0.6 mol per kg ingested OM).

Key Words: NFC, Fermentation, Carbohydrate


Supplemental methionine improves milk protein yield with diets low in CP either through stimulation of microbial CP synthesis or through escape of methionine. Previous work suggested that HMB (2-hydroxy-4-methylthiobutanoic acid) might promote changes in ruminal bacterial populations. DGGE (denaturing gradient gel electrophoresis) and RIS-LP (ribosomal intergenic spacer length polymorphism) were used to monitor treatment-induced changes in microbial populations in the ruminum and omasum of cattle fed control, HMB, dl-methionine, or HMBi (isopropyl ester HMB; estimated 50% rumen protection) in a 4 x 4 Latin square design. For DGGE, a hypervariable region of the 18S rRNA gene was amplified from the extracted DNA using PCR with a ciliate-specific primer set. Amplicons were separated on an 8% acrylamide gel with a 28-36% denaturing gradient. The banding patterns
were similar for both ruminal and omasal samples and were not different among treatments. Protozoal counts were not different among treatments (P > 0.05) in ruminal or omasal samples. Generic protozoal counts were not different (P > 0.05) among treatments, corresponding with similar banding profiles from DGGE. Multivariate statistics showed no difference (P > 0.05) in genetic distribution. protozoa in ruminal vs. omasal samples, supporting absence of selective retention of Isotrichs in the rumen. Extracted DNA from omasal samples was amplified in PCR using S926f and L189r primers for RIS-LP analysis. Amplicons vs. omasal samples, supporting absence of selective retention of Isotrichs in the rumen.

**Key Words:** DGGE of Ruminal Protozoa, RIS Analysis, HMB

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**940 Effects of different components of garlic oil on rumen microbial fermentation in a continuous culture system.** Marta Busquet1, Sergio Camel1, Alfred Ferrer1, and Christopher Kamel2, 1Universitat Autonoma de Barcelona, Spain, 2University of Leeds, UK

Preliminary in vitro batch culture trials using garlic oil (G) and 4 of its components (diethyl sulphide = Dd; diethyl disulphide = Dd; allyl mercaptan = Am; and allin = A) indicated that only the doses of 30 and 300 mg/L of G, Dd, and Am modified rumen microbial fermentation profile. Eight 1-L dual flow continuous culture fermenters were used in three periods (8 d) to study the effects of these extracts on rumen microbial fermentation profile in a long-term in vitro study. Fermenters were fed 95 g/d of the 50 to 50 forage to concentrate diet. Treatments were: no extract or negative control (C), G (300 mg/L = G10), Dd (30mg/L = Dd), 300mg/L = Dd10), and Am (30mg/L = Am; 300mg/L = Am10). Fermenters were maintained at constant temperature (39°C), pH (6.4) and solid (5%/h) and liquid (10%/h) dilution rates. Each day, a sample was taken 2 h after the morning feeding for the determination of ammonia (NH3) N and volatile fatty acids (VFA). During the last 3 days, samples were taken at 0, 2, 4, 6 and 6 h after the morning feeding, and analyzed for peptide (Pep), aminocid (AA) and NH3 N concentrations. Total VFA were similar across treatments (122.2 mM). Acetate proportion (mol/100mol) was lower in G10 (48.0), Dd (53.5), Dd10 (49.2), and Am10 (51.0) compared with C (60.7). Propionate proportion with G10 (30.5) compared with C (21.8). Butyrate proportion (mol/100mol) was higher in Dd10 (20.3) compared with C (12.4). Average Pep-N concentration (mg/100ml) was similar in all treatments. Average AA-N concentration (mg/100ml) tended to increase (P = 0.07) in Dd10 (4.6) compared with C (2.9), and the average NH3 N concentration (mg/100ml) tended to increase (P = 0.08) in Am10 (15.4) compared with C (10.5), suggesting that Am10 stimulated deamination. All garlic oil components resulted in similar effects to those observed in G10. However, G10 had stronger effects (and similar to ionophore antibiotics) which could be explained by a synergistic activity between its constituents.

**Key Words:** Rumen Fermentation, Plant Extracts, Garlic

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**941 Effects of Lactobacillus acidophilus and Propionibacterium freudenreichii on performance and rumen characteristics of Holstein dairy cows in mid-lactation.** M. L. Raeth-Knight, J. G. Linn, University of Minnesota, St. Paul.

A lactation study (Study 1) was conducted from February 12, 2003 to May 6, 2003. Thirty-nine multiparous and eighteen primiparous Holstein cows were blocked by parity and randomly assigned to one of three dietary treatments; remaining on treatment for 84 days. Treatments included: 1 x 109 cfu/day live Lactobacillus acidophilus strain LA747 and 2 x 109 cfu/day live Propionibacterium freudenreichii strain PF24 (Diet A), 1 x 109 cfu/day live Lactobacillus acidophilus strain LA747, 2 x 109 cfu/day live Propionibacterium freudenreichii strain PF24, and 5 x 109 cfu/day Lactobacillus acidophilus strain LA45 (Diet B) and lactose (Control- Diet C). Treatments were administered by mixing 45 grams of finely ground corn with 5 grams of live microbial product or lactose and top dressing on the TMR once daily. All cows received the same TMR: 12.7% hay, 46.2% corn silage and 41.1% concentrate (DM basis). A Latin square study (Study 2) was conducted concurrently with the lactation study. Three rumen cannulated, multiparous Holstein cows were randomly assigned to dietary treatments A, B, and C in a 3 x 3 Latin square design with 28 days period; 21 days of adaptation and 7 days of data collection. In Study 1, there was no difference (P > .1) in average DM intake (36.68, 36.18 and 36.12 kg/d) or 4% FCM (36.68, 35.18 and 36.12 kg/d) for treatments A, B, and C, respectively. There was no difference (P > .1) in fat, protein or lactose yield, milk urea nitrogen or somatic cell count. Feed efficiency was 1.53, 1.49 and 1.49 kg FCM per kg of DM intake for treatment A, B, and C, respectively. For study 2, there was no difference (P > .1) in rumen pH, concentration of ammonia or total volatile fatty acids (VFA) measured at 0, 1, 3 and 6 hours post feeding. For treatments A, B, and C, average rumen pH was 6.20, 6.15 and 6.15 while the average low, 3 hours post feeding, was 6.01, 5.98 and 5.96. Across treatments, average ammonia concentration was 8.76, 19.69, 12.55, and 8.37 mg/dl of rumen fluid at 0, 1, 3 and 6 hours post feeding.

**Key Words:** Direct Fed Microbial, Mid-Lactation, Ruminant

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**Impact of feeding high free fatty acid whole cottonseed to Holstein cows in mid-lactation.** J. K. Bernard, J. Siciliano-Jones, and T. C. Wedegaertner, 1The University of Georgia, Athens, 2FARME Institute, 3Cotton Incorporated.

Whole cottonseed (WCS) is used as a source of energy, protein, and fiber by many dairy producers. The concentration of free fatty acids in the oil (FFA) may be elevated after tropical storms delay harvest resulting in concentrations exceeding 12% of the oil. These seed are considered to be lower than the 15% considered to be of off-quality. Limited data are available on the feeding value of WCS. Approximately 300 lactating Holstein cows were used in a 3 x 3 Latin square trial to determine the impact of feeding whole cottonseed...