Ruminant Nutrition: Dairy: Forages and Fiber

421 Milk production responses to soybean meal and canola meal in dairy cows fed grass silage based diets—A meta-analysis. P. Huhtanen*[1], M. Hetta[1], and C. Swensson[2], *[1]Swedish University of Agricultural Sciences, Umeå, Sweden, [2]Swedish Dairy Association, Lund, Sweden.*

Most feed protein evaluation predict a higher metabolizable protein (MP) for soybean meal (SBM) compared with canola meal (CM), but the data from production trials comparing SBM and CM have generally failed to prove this. A data set from production trials in which SBM, CM, heat-treated-CM (TCM) and a mixture of SBM and fishmeal (SFM) was collected from milk production trials. Prerequisites of the data to be included were that detailed information of diet composition, intake and milk production were reported and that the protein feeds were fed at least at 2 levels. Grass silage or mixtures of grass and whole-crop silages were used as forages and cereal grains (barley, oats and corn) were the major concentrate ingredients. The data set included in total 292 treatment means (122 comparisons) that were distributed as follows: SBM 46 (22), CM 120 (55) TCM 82 (29) and FSM 44. A mixed model regression analysis with random study effect was used to compare intake and production responses between the protein sources. Dietary CP concentration or intake of CP and ME were used as independent variables. All protein sources increased DMI, but the responses of 0.29 and 0.34 kg/1%-unit increase in dietary CP concentration was greater ($P < 0.01$) compared with SBM (0.11) with SFM displaying an intermediate response (0.20). Feeding CM or TCM produced greater ($P < 0.01$) milk yield responses than SBM (3.4 ± 0.19 and 3.7 ± 0.25 vs. 2.1 ± 0.25) per kg increase in CP intake. However, because of different DMI effects ECM responses to incremental ME intake were similar (0.16 to 0.18 kg ECM/MJ ME). Marginal milk protein yield responses (g/kg increase in CP intake) were greater ($P < 0.01$) with CM (136 ± 5.4) and TCM (133 ± 8.5) compared with SBM (988.0), but not when compared with SFM (125 ± 9.4). The difference between CM and SBM was even greater when expressed per kg MP predicted according to NRC (2001) system (381 ± 18 vs. 197 ± 17 g/kg MP). It is concluded that CM can be substituted for SBM on isonitrogenous basis without compromising milk production, and that MP systems tend to underestimate productive value of CM compared with SBM.

Key words: canola meal, milk production, soybean meal

422 Intake and milk production of dairy cows fed diets including low lignin/high fiber digestibility corn silage. N. B. Litherland*[1], H. G. Jung[1,2], and J. G. Linn[1], *[1]University of Minnesota, St Paul, [2]USDA-ARS, St Paul, MN.*

The objective of this study was to evaluate the effect of increasing digestible NDF content of lactating dairy cow diets on DMI and milk yield by feeding increasing proportions of low lignin (BMR) corn silage (CS). Control (B73) and BMR (B73bm3) inbred corn lines were ensiled in a poly-bag in September 2009. Silage pH was 3.8 for both silages and lactic-to-acetic acid ratio was 3.7:1 for control and 3.2:1 for BMR silages. Control and BMR CS, respectively, contained (DM-basis) 9.7 and 8.3% CP, 46.6 and 45.8% NDF, 2.9 and 2.6% lignin, and 15.8 and 17.7% starch. In vitro 48 h NDF digestibility was greater for BMR (72.1%) than control (57.0%) CS. Fifty Holstein and cross-bred dairy cattle producing 43.5 kg milk/d and 80 d in milk were assigned to 5 treatments. Diets included 0%BMR-100% Control (0BMR), 25%BMR-75% Control (25BMR), 50%BMR-50%Control (50BMR), 75% BMR-25%Control (75BMR), or 100%BMR-0%Control (100BMR) CS. All diets contained equal amounts of CS (43% of diet DM) and were balanced for 25 kg DMI and 43 kg of milk. Because the control CS contained less grain, more dry ground corn was added to the amount of control CS in the diets to keep starch equal. Diets contained 51.1% DM, 23.3% forage NDF, 17.2% CP, 19.0% ADF, 31.1% NDF and 24.5% starch. Cows were fed the diets for 56 d from February through April 2010. Data were analyzed using Proc Mixed in SAS as a completely randomized design with repeated measures and the least significant difference test was used for mean separations when main effects were significant ($P < 0.05$). DMI averaged 24.5 kg/d (SEM = 1.9) and was similar among diets (100BMR DMI was only 1.9 kg/d greater then 0BMR). Milk yield and 3.5%FCM yield averaged 48.6 kg/d (SEM = 2.1) and 37.1 kg/d (SEM = 1.8), and were similar among diets (100BMR averaged 1.7 kg/d greater milk yield than 0BMR). Dairy efficiency was not different and averaged 1.6 (SEM = 0.1). Milk fat and protein were similar among diets and averaged 3.2% (SEM = 0.1) and 3.1% (SEM = 0.1), respectively. Although BMR CS typically improves cow performance, in this trial greater in vitro digestibility of CS NDF did not enhance DMI or milk production.

Key words: corn silage, fiber, digestibility

423 Effects of supplementing starch or sugar pre-and postpartum to dairy cows fed TMR with wheat straw or grass hay prepartum: Performance, metabolism and health. N. B. Litherland*[1], L. Davis[2], S. Emanuele[2], and H. Blalock[2], *[1]University of Minnesota, St Paul, [2]Quality Liquid Feeds Inc., Dodgeville, WI.*

The objectives of this study were to determine if varying prepartum forage source and periparturient supplemental energy source affects periparturient performance and health. Sixty multiparous Holstein and crossbred cows were used in a completely randomized design with 4 treatments:1) Wheat straw (WS) prepartum (12.5% CP, 42.2% NDF, and 1.4 Mcal/kg NEL) + corn pre and postpartum (WSC), 2) WS prepartum (12.7% CP, 41.8% NDF, and 1.4 Mcal/kg NEL) + molasses-based Liquid Feed (LF) pre and postpartum (WSL), 3) Grass hay (GH) prepartum (13.8% CP, 37.8%NDF, and 1.5 Mcal/kg NEL)+corn pre and postpartum (GHC), 4) GH prepartum (13.9% CP, 37.4%NDF, and 1.5 Mcal/kg NEL) + LF pre and postpartum (GHL). Prepartum dietary treatments were initiated at dry off and postpartum diets were fed from parturition through 56 d in milk. After calving, cows were fed one of 2 diets formulated to support 45 kg/d of 3.5% FCM. The LF diets provided 2.7% of diet DM prepartum as supplemental sugar, and 1.5% postpartum. Data were analyzed using PROC MIXED in SAS as a randomized design with 4 treatments. WSC and GHC tended ($P = 0.08$) to consume more starch and WSL and GHL cows consumed more ($P < 0.05$) sugar. For WSC, WSL, GHC, and GHL treatments, prepartum DMI averaged 13.3, 12.8, 15.0 and 13.6 kg/d (SEM = 0.9; $P = 0.45$), postpartum DMI averaged 20.1, 17.8, 21.0 and 18.8 kg/d (SEM = 1.0; $P = 0.15$), yield of 3.5% FCM averaged 45.8, 45.2, 43.1 and 44.2 kg/d (SEM = 1.7; $P = 0.71$), and dairy efficiency (kg 3.5% FCM/kg DMI) averaged 2.4, 2.6, 2.2, and 2.4 (SEM = 0.1; $P = 0.27$), respectively. Yield and percentage of fat and protein were similar. There were no differences in prepartum or postpartum condition score or body weight loss. Prepartum energy balance tended ($P = 0.06$) to be higher for WSC and GHC compared with WSL and GHL. Prepartum serum NEFA were higher for WSL and GHL (SEM = 18.9; $P < 0.05$) and averaged 85.5, 177.1, 92.2, and133.1μ/mL for WSC, WSL, GHC,

and GHL. In conclusion, cows fed diets varying in energy and forage source performed similarly during the periparturient period.

Key words: energy source, forage, transition cow

424 Alternative models of kinetics impact indigestible neutral detergent fiber and estimates of ruminal digestibility. D. R. Mertens*, *Mertens Innovation & Research LLC, Belleville, WI.*

This project evaluated the interactions among models of digestion kinetics and methods of estimating indigestible NDF (iNDF) on steady-state predictions of ruminal digestibility. In vitro fermentations > 96 h suggest that some forages may have 2 pools of potentially digestible NDF. A sequential multi-pool equation was used to simulate digestion curves from known inputs (indigestible fraction = 0.2 or 0.4 of NDF; slowly digestion fraction = 0.3, 0.2, or 0.1 of NDF; lag rate = 0.25/h; fast and slow digestion rates = 0.06, 0.12, or 0.18 and.012, 0.008 or 0.004/h) that mimic typical digestion kinetics of alfalfa (A) and grass (G) forages. Kinetic parameters were estimated from simulated data using SAS NLIN for a 2-pool model (discrete lag, single digestible and iNDF pools) using results for 3, 6, 9, 12, 18, 24, 36, 48, 60 and 72 h; and for a 3-pool model (discrete lag, rapidly and slowly digesting and iNDF pools) using results for 6, 12, 24, 48, 72, 96, 120, 144, 192 and 240 h. Fitting a 2-pool model to simulated 3-pool digestion curves resulted in compromised estimates of rates of digestion and iNDF. The 2-pool model generated iNDF that were 1.3 (A) and 1.6 (G) larger than the known iNDF; whereas, rates of digestion were 0.63 (A) and 0.67 (G) of the known fast digestion rate. The 2-pool kinetic parameters resulted in ruminal digestibilities that were 0.95 of the known calculated values for A and G. For a 2-pool model, iNDF is estimated most closely by 72 h measurements. Even with no random variation and long fermentation times, fitting the 3-pool model generated iNDF pools that were 0.88 (A) and 0.85 (G), and fast and slow digestion rates that were 0.7 to 0.8 of the known values. The 3-pool model resulted in ruminal digestibilities that were 0.98 of the true values for A and G. At 240 h, the residue was 1.1 to 1.2 larger than the known iNDF. It was concluded that adding a second slowly digesting pool to describe NDF digestion results in improvements in the estimation of ruminal fiber digestion that are small in relation to the variation among in vitro measurements and kinetic parameters using nonlinear estimation.

Key words: digestion kinetics, rate, indigestible fiber

425 Comparison of alternative methods, sample grinds, and fermentation times for determining indigestible neutral detergent fiber. J. Boyd*[1] and D. R. Mertens[2], *[1]US Dairy Forage Research Center, Madison, WI, [2]Mertens Innovation & Research LLC, Belleville, WI.*

The objectives of this study were to evaluate the effects of sample grind, fermentation method, and time on the determination of indigestible neutral detergent fiber (iNDF). Samples of alfalfa hay and silage; corn stalks and silage; and ryegrass and mixed grass hays were ground through 2-mm and 1-mm screens in a cutter mill and 1-mm screen in a cyclone mill. Both 1-mm ground samples were fermented in flasks (in vitro, IV) or in F57 filter bags in a rotating jar system for 0, 48, 72, 96, or 144 h. In situ (IS) samples were fermented for 0, 48, 72, 96, 144, 240, and 288 h in animals fed either TMR, alfalfa silage, or grass hay, and these same donors were used to make a composite inoculum for the in vitro and rotating jar fermentations. For in situ, 2-mm samples were fermented in Ankom in situ bags and 1-mm cyclone samples were fermented in F57 filter bags. Fermentation residues were extracted in neutral detergent using crucibles with silica sand for IV or using the A200 fiber analyzer for all bags. Only samples fermented for > 96 h were evaluated as estimates of iNDF. Data were analyzed using Proc MIXED of SAS with run within method and repetition within run as random variables. Across all samples, 288 h IS obtained the smallest iNDF for the 1- and 2-mm grinds, and they were not different ($P < 0.05$) from 1- and 2-mm grinds of 240 h IS or from both 1-mm grinds for 144 h IV. Bags appeared to impede measurement of iNDF. At 144 h, the IV results of both grinds were lower ($P < 0.05$) than both grinds in F57 bags in the rotating jar system and the 1-mm cyclone grind in F57 bags fermented IS. The 2-mm grind fermented in IS bags at 144 h IS were not different from IV results at 144 h. In general, IS fermentation took nearly twice as long to obtain iNDF similar to IV results. Differences in iNDF among treatments were greater for more slowly fermenting substrates (corn stalks and mixed grass hay). In summary, measurement of iNDF is affected by time and fermentation system, but less so by grinding through 1- or 2-mm screens.

Key words: Indigestible fiber, digestion kinetics, in vitro, in situ

426 Effects of daily ingredient dry matter adjustment of total mixed ration using Intelligent Ration Monitoring (IRM) NIR forage analyzer on commercial dairy farm performance. D. N. L. da Silva*[1], A. Barbi[2], A. Ghiraldi[2], D. Allen[3], and N. B. Litherland[1], *[1]University of Minnesota, St Paul, [2]Dinamica Generale, Poggio Rusco, Italy, [3]Gar-Lin Dairy, Eyota, MN.*

The objectives of this study were to determine the effects of daily adjustment of ingredient dry matter (DM) using a near-infrared reflectance (NIR) IRM (Intelligent Ration Monitoring) system on diet composition, dry matter intake (DMI), and milk and component yield. We hypothesized that daily mechanical adjustment of DM would reduce TMR DM variability and improve dairy efficiency (DE) compared with conventional ingredient DM adjustment (weekly hand sampling). Five hundred dairy cows in 2 pens (n = 250) on a commercial dairy were used in a crossover design with 9 week periods. Pens were balanced by milk yield (52.9 and 51.8 kg/cow/d) and days in milk (110.5 and 111.8). Two dietary treatments: (Control) weekly correction of ingredient DM of corn silage, alfalfa silage and high moisture corn by drying for 12 h 100C oven; (IRM) the IRM system scanned individual ingredients and adjusted DM at each feeding. Diets had the same composition and only varied by method of DM adjustment. Cows were fed twice and milked 3 times daily. Data were analyzed using Proc Mixed in SAS with repeated measures when appropriate and PDIFF used for mean separation when main effects were significant ($P < 0.05$). Control and IRM TMR DM averaged 45.9 and 46.0% (SEM = 0.83;P = 0.93). TMR starch, CP, ADF and NDF were similar. Nutrient composition of TMR refusals was not different. DMI per cow averaged 26.5 and 26.9 kg/d (SEM = 1.3; $P = 0.7$). DM refusal %/cow/d averaged 5.0 and 4.7 (SEM = 1.5; $P = 0.6$). Milk and 3.5% FCM yield averaged 52.9 and 52.8 (SEM = 1.3; $P = 0.9$) and 56.5 and 54.6 (SEM = 2.3; $P = 0.1$) for control and IRM. Percent milk protein was higher (2.9 vs. 3.0 SEM = 0.2) (Trt × week; $P < 0.05$) for IRM but protein yield was similar between treatments. Milk fat % and yield averaged 3.8 and 3.7 (SEM = 0.2; $P = 0.7$) and 2.0 and 1.9 kg/d (SEM = 0.1; $P = 0.3$) for control and IRM. DE averaged 2.2 and 2.0 (SEM = 0.1; $P = 0.1$) for control and IRM. IRM cows performed as well as those fed using traditional DM adjustment.

Key words: NIR, precision feeding, dry matter

427 Effects of prepartum supplementation of starch or sugar to dairy cows fed TMR with thirty percent wheat straw or grass hay on colostrum yield and composition. N. B. Litherland*[1], L. Davis[2], S. Emanuele[2], and H. Blalock[2], *[1]University of Minnesota, St Paul, [2]Quality Liquid Feeds Inc., Dodgeville, WI.*

Sixty multiparous Holstein and crossbred cows, balanced by 305ME and parity, were used in a completely randomized design (CRD) with 4 prepartum treatments: 1) Wheat straw (WS) + corn (WSC) (12.5% CP, 42.2% NDF, 20.1% starch, 3.6% sugar and 1.4 Mcal/kg NEL), 2) WS + molasses-based Liquid Feed (LF) (WSL) (12.7% CP, 41.8%NDF, 18.7% starch, 6.3% sugar and 1.4 Mcal/kg NEL), 3) Grass hay (GH) + corn (GHC) (13.8% CP, 37.8%NDF, 20.1% starch, 5.1% sugar and 1.5 Mcal/kg NEL), 4) GH + LF (GHL) (13.9% CP, 37.4%NDF, 18.7% starch, 7.9% sugar and 1.5 Mcal/kg NEL). The LF diets provided 2.7% of diet dry matter as supplemental sugar. Prepartum diets were formulated to meet NRC, 2001 recommendations at 28 kg DMI/d. Treatments were fed from dry-off until calving; 41 d SEM = 2.0. Data were analyzed using Proc Mixed in SAS as a CRD and PDIFF used for mean separation when main effects were significant ($P < 0.05$). WSC and GHC tended ($P = 0.08$) to consume more starch and WSL and GHL cows consumed more ($P < 0.05$) sugar prepartum. DMI averaged 13.3, 12.8, 15.0 and 13.6 kg/d SEM = 0.9; $P = 0.45$). Calf birth weight averaged 46.1, 48.3, 49.1, 48.0 kg ($P = 0.91$; SEM = 3.0). First-milking colostrum yield averaged 9.2, 9.6, 9.0, and 10.9 kg for WSC, WSL, GHC, and GHL ($P = 0.67$; SEM = 1.6). Among treatments, 13.3% of cows produced <5.0 kg of colostrum. Pearson correlation for colostrum yield, prepartum intake of DM, OM, CP, NDF, ADF, starch, and DMI one week prepartum were not significant. Colostrum yield tended to be positively correlated with prepartum sugar intake ($P = 0.07$). Colostrum DM % tended to be higher for WSL compared with WSC ($P = 0.07$; SEM = 1.2) and averaged 26.6, 31.1, 30.8, and 28.3 for WSC, WSL, GHC, and GHL. Colostrum minerals were analyzed using inductively coupled plasmid analysis. Colostrum mineral yield was similar and averaged (SEM) 25.4g (3.7) Ca, 21.6 g (3.1) P, 3.8 g (0.6) Mg, 15.7 g (2.3) K, 15.0 g (2.0) S, and 6.7 g (1.0) Na. Prepartum sugar intake, colostrum yield and composition should be further explored.

Key words: transition cow, colostrum, sugar

428 Effects of corn gluten feed and effective NDF on ruminal pH and productivity of lactating dairy cattle. M. L. Sullivan*[1], K. N. Grigsby[2], and B. J. Bradford[1], *[1]Department of Animal Science and Industry, Kansas State University, Manhattan, [2]Cargill Incorporated, Blair, NE.*

Corn gluten feed (CGF), a by-product of the wet milling industry, is commonly substituted in lactating dairy rations for corn, corn silage, and alfalfa hay. Previous research at Kansas State University showed that increasing CGF in the diet decreased ruminal pH. The objective of this study was to maintain at least 10% of particles ≥18 mm in length across diets. We hypothesized that as CGF increased in the diet, DMI and milk yield would increase while ruminal pH would be maintained. Seven ruminally cannulated, lactating Holstein cows (4 multiparous, 3 primiparous) were used in an incomplete 4 × 4 Latin square design. Treatments included 0, 11, 23 or 34% CGF while utilizing alfalfa to maintain particle size. Four 21 d periods were used with 17 d of adaptation and 4 d of sample collection. Free floating ruminal pH probes were utilized during sampling periods and recorded pH every 5 min. Particle size of TMR and orts were analyzed using a Penn State Particle Separator. Across treatments CP and NDF were held constant. Results were analyzed with mixed models to test the fixed effect of treatment. All diets contained >10% of particles ≥18 mm; however, as CGF increased, the percent of particles ≥18 mm significantly ($P = 0.01$) decreased. Interestingly, with increasing CGF, cows sorted for the particles ≥18 mm ($P = 0.03$) while sorting against particles on the bottom screen ($P = 0.002$) and pan ($P = 0.01$). With increasing CGF, ruminal pH was not affected, yet DMI ($P = 0.02$) and milk yield ($P = 0.02$) significantly increased in a quadratic fashion with peak response for the 23% diet. Milk protein, lactose and fat percentages were not affected; however, milk protein ($P = 0.004$) and lactose ($P = 0.02$) yields showed a significant increase as a result of the increased milk production. Additionally, efficiency was not affected by the treatments as there were no differences in ECM/DMI. Thus it was demonstrated that if minimal particle size is maintained as CGF increases in the diet, DMI and milk yield increase while maintaining ruminal pH.

Key words: corn gluten feed, ruminal pH, particle size

429 Feeding forage cubes to identify divergence for residual feed intake in dairy cows. G. C. Waghorn*[1], K. A. Macdonald[1], S. R. Davis[2], and R. J. Spelman[3], *[1]DairyNZ, Hamilton, New Zealand, [2]Via-Lactia Biosciences, Auckland, New Zealand, [3]Livestock Improvement Corporation, Hamilton, New Zealand.*

Selection for divergence between individuals for efficiency of feed utilization (residual feed intake, RFI) has widespread application in the beef industry and is usually undertaken when animals are fed diets based on silages with grain. The objective of this research was to develop a feeding system (using Gallagher, Hamilton, New Zealand, electronics) and measure RFI for growth in Holstein/Friesian heifers (aged 5–9 mo), and evaluate divergent individuals for RFI for lactation. A forage diet (alfalfa cubes) was fed because the New Zealand dairy industry (4.4 milking cows in lactation) relies heavily on forage feeding. Genetic markers will be identified for the trait. The evaluation was undertaken over 3 years with 1052 animals fed in a facility for 6 weeks, and weighed 3 x weekly. The mean age at entry was 170 d, BW 171 kg, and mean daily dry matter (DM) intakes averaged 7.9 kg. BW gain (all animals) averaged 0.88 kg/day. RFI was determined as the residuals from the regression of mean intake on mean $BW^{0.75}$ and daily BW gain of individuals. Actual and fitted intakes were strongly related (R2 = 0.82). In terms of gross efficiency (feed intake/BW gain), RFI + year explained 43% of the variation, BW gain + year, 66% and RFI + BW gain + year 79% of variation (all $P < 0.001$). Daily BW gains (kg) of the most and least efficient 10% averaged 0.88 sd 0.15 and 0.88 sd 0.12 ($P = 0.568$) respectively, and the divergence between mean intakes was 1.72 kg DM/d. Comparable values for the most and least efficient 5% were 0.86 sd 0.15 and 0.90 sd 0.12 kg/d respectively ($P = 0.067$), and the divergence in mean intakes was 2.24 kg DM/d. Justification for using RFI for gain in peri-pubertal heifers to identify divergence for lactation was based on the biochemical bases of efficiency for production (milk or meat) and maintenance, and the high proportion of dietary energy used for maintenance in growing cattle and over a cows lifetime. The selection is currently being evaluated in lactating cows.

Key words: residual feed intake, forages, divergence

430 A mathematical model to predict the size and rate of digestion of a fast and slow pool of NDF and the indigestible NDF. E. Raffrenato*, C. F. Nicholson, and M. E. Van Amburgh, *Cornell University, Ithaca, NY.*

Many models that predict rate and extent of digestion of neutral detergent fiber (NDF) in the rumen assume first-order processes, in which the rates of digestion and passage are proportional to the mass of NDF in the rumen. Our objective was to improve the prediction of digestible NDF and to quantify, using a minimum of fermentation points, 2 pools of potentially digestible NDF, pdNDF1 and pdNDF2, and their respective rates. Based on fermentations from 0 to 240 h among 34 forages (grasses, conventional and bmr corn silages, alfalfas) 3 pools were described by NDFt = pdNDF1 * $e^{-k1(t-L)}$ + pdNDF2 * $e^{-k2(t-L)}$ + iNDF, where NDFt is the residue at time t; L is the lag; k1 is the rate of digestion of pdNDF1; k2 is the rate of digestion of pdNDF2; and iNDF the indigestible NDF on NDF basis. A non-linear estimation allowed the computation of the pool sizes and respective rates. Using 3 points on the degradation curve, with 240 h as the proxy for iNDF, we optimized the same model in Vensim® (Ventana Systems Inc., Belmont, MA, 2005) to obtain rates and pools. In addition, the same optimization was also performed with 2 points and a forage group-specific range for iNDF. Parameters (with and without iNDF) obtained per forage were compared with kinetics data from the non-linear estimation, using R^2 and RMS at convergence for ranking purposes, for the whole equation, and RMSE and MSPE. The highest R^2 (0.98) and lowest RMS (0.0010) were obtained when using 48, 120 and 240 h of NDF residual or when using 30 and 120 h and a range for the forage group-specific iNDF (R^2 = 0.92; RMS = 0.0021). Correlations were in both cases consistently high for all parameters (r = 0.76 to 0.99). Results demonstrate that a better description of the heterogeneity of NDF disappearance is possible with a minimum of fermentation time points. Due to the variable nature of the pool sizes and rates, forage specific equations should be developed for better estimations of the forage specific characteristics and iNDF estimation.

Key words: modeling, NDF digestibility, rate of digestion

431 Rates of particle size reduction and passage are faster for legume compared to C3 grass resulting in lower rumen fill and less effective fiber. K. L. Kammes* and M. S. Allen, *Michigan State University, East Lansing.*

Rates of particle size reduction in, and passage from, the rumen were evaluated for diets containing legume (alfalfa, A) or C3 grass (orchardgrass, O) silages as the sole forage using 14 ruminally and duodenally cannulated cows. The experiment was a crossover design with 2 18-d treatment periods. Silages were chopped to 1 cm theoretical length of cut and contained 42.3 and 58.2% neutral detergent fiber (NDF) for A and O, respectively. Both diets contained 25% forage NDF and 30% total NDF. Feed, orts, rumen, and duodenal samples were wet sieved to fractionate particles above (large, L) and below (small, S) 2.36 mm. Indigestible NDF (iNDF), determined by 240 h in vitro fermentation, was used as a flow marker. Milk yield (36 kg/d), milk components, and dry matter intake (24 kg/d) were similar for A and O ($P > 0.10$). Particle size distributions of NDF consumed (75% L and 25% S) were similar for both treatments, but iNDF (% of total NDF) consumed was much greater for A compared with O (54.2 vs. 27.4%, $P < 0.0001$). Rumen pools of L NDF, total NDF, and dry matter (3.2 vs. 4.4 kg, 6.2 vs. 6.8 kg, and 10.6 vs. 12.6 kg, respectively; $P < 0.05$) and total rumen contents wet weight and volume (83 vs. 93 kg and 98 vs. 109 L, respectively; $P < 0.01$) were smaller for A compared with O. Ruminating time per kg forage NDF consumed was 7% greater for O than A ($P < 0.05$). Rate of reduction of iNDF from L to S was greater for A than O (5.7 vs. 3.1%/h, $P < 0.0001$) as was rate of passage of iNDF and potentially digestible NDF in S (6.3 vs. 4.9%/h, $P < 0.05$). The proportion of NDF in the rumen below the threshold for passage (S) was 62.9 and 55.3% for A and O, respectively. However, the rate of passage of iNDF in S was positively correlated with the rate of reduction of iNDF from L to S for A ($P < 0.05$) but not for O ($P = 0.56$). Faster rate of passage of S for A suggests less selective retention because of a smaller rumen pool of L NDF for A compared O. Although particle size reduction is a prerequisite to passage, it is less of a constraint to passage for C3 grass compared with legume.

Key words: particle size, passage kinetics, rumen fill

432 Individual variability of NDF intake and feed conversion efficiency in pasture-based systems. S. C. Garcia*[1], F. Bargo[2], and R. K. Jhajj[1], [1]*The University of Sydney, Camden, NSW, Australia,* [2]*Elanco Animal Health Southern Cone (Argentina & Chile), Buenos Aires, Argentina.*

Mean daily intake and milk yield data of lactating Holstein-Friesian dairy cows from 7 studies (mostly grazing) conducted in USA, Australia and New Zealand were combined to quantify the variability in neutral detergent fiber intake (NDFI) and its relationship with feed conversion efficiency in pasture-based systems. Intake of grazing cows was estimated by external markers. Within study, data from individual cows were classified according to milk yield level (low, medium or high) to avoid confounding effects with study of origin. Data were analyzed using a mixed-effects model and by regression analysis. On average, mean body weight (BW) was similar ($P \geq 0.05$) across the 3 groups. Milk yield varied from 17 to 30 L/cow $^{-1}$) but mean dry matter intake (DMI) increased ($P \leq 0.001$) by only 13% (as % of BW) between low and high milk yield groups, respectively. Mean daily NDFI (1.28% body weight) was similar ($P \geq 0.05$) across the 3 groups and close to the widely accepted upper maximum (≈1.2% BW) for lactating cows. However, the variation in NDFI among individual cows was much larger than expected. Consistently across all studies NDFI (%BW) by individual cows increased linearly as total actual daily NDFI (kg/cow) increased, when a flatten of the relationship would be expected to occur at ≈1.2% BW if a true physical limitation to intake were present. The NDFI by individual cows ranged from 0.5 to 2.9% of BW, with the upper 20% of the cows in the data set eating in excess of 1.6% BW. The observed variability was similar in pattern across all studies, suggesting it was more related to intrinsic animal than feed factors. Feed conversion efficiency increased as milk yield increased, but was unrelated ($P \geq 0.05$) to individual variation in DMI per cow. Feed conversion efficiency decreased as NDFI (% BW) increased, particularly for cows in the high and medium yield categories. Results indicate that using a fixed value of maximum potential NDFI for individual cows would be misleading, particularly for grazing animals, highlighting the need of more individualized approaches to feeding management of cows in pasture–based systems.

Key words: NDF intake, dairy cows, feed conversion efficiency