

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 generic distribution of protozoa in ruminal vs. omasal samples, supporting absence of selective retention of Isotrichs in the rumen. Extracted DNA from omasal contents was amplified in PCR using S926f and L189r primers for RIS-LP analysis. Amplicons containing the complete RIS and parts of the flanking rRNA genes were separated on a 4% polyacrylamide gel. The RIS-LP gel image was exported into image analysis software. Cluster analysis of banding profiles grouped the treatments together, suggesting that bacterial populations differed among treatments. Source of methionine appeared to change ruminal bacterial but not protozoal populations. Future research will characterize bacterial populations altered by HMB supplementation.

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

940 Effects of different components of garlic oil on rumen microbial fermentation in a continuous culture system. Marta Busquet¹, Sergio Calsamiglia^{*1}, Alfred Ferret¹, and Christopher Kamel², ¹Universitat Autònoma de Barcelona, Spain, ²University of Leeds, UK.

Preliminary in vitro batch culture trials using garlic oil (G) and 4 of its constituents (diallyl sulphide = Ds; diallyl disulphide = Dd; allyl mercaptan = Am; and allicin = A) indicated that only the doses of 30 and 300 mg/L of G, Dd, and Am modified rumen microbial fermentation profile. Eight 1.3-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 and 6 h after the morning feeding, and analyzed for peptide (Pep), aminoacid (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 (mol/100mol) was higher in 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

941 Effects of *Lactobacillus acidophilus* and *Propionibacterium freudenreichii* on performance and rumen characteristics of Holstein dairy cows in mid-lactation. M. L. Raeth-Knight* and 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 10⁸ 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 day periods; 21 days of adaptation and 7 days of data collection. In Study 1, there was no difference ($P > .1$) in average DM intake (23.90, 23.60 and 24.19 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, 12.53, 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

942 Effect of calcium source on ruminal soluble calcium and microbial fermentation. E. J. Baird^{*1}, V. Fellner¹, S. J. McLeod¹, J. W. Spears¹, and F. R. Valdez², ¹Department of Animal Science, North Carolina State University, Raleigh, ²Kemin Americas, Des Moines, IA.

A study was conducted to determine the effect of Ca level and source on ruminal soluble Ca concentration and microbial fermentation in continuous culture fermentors. Treatments consisted of control diet (0.18% Ca) or the control supplemented with 0.60% Ca from either: 1) CaCO₃, 2) Ca propionate-prilled (CaP, NutroCAL#8482) or 3) CaP-powder. Fermentors were fed 14 g DM/d of a diet (DM basis) consisting of 35% corn silage, 18% soybean meal, 15% corn, 22% cottonseed hulls, and 10% whole cottonseed. Following a 2-d stabilization period, fermentors were sampled over a 4-d collection period. Each treatment was replicated five times. Calcium supplementation of the control diet increased ($P < 0.01$) ruminal soluble Ca concentrations. Ruminal soluble Ca concentrations were higher ($P < 0.01$) in cultures receiving CaP treatments compared to CaCO₃. Ruminal pH was higher in Ca-supplemented diets compared to control ($P < 0.01$), and CaCO₃ was higher ($P < 0.05$) than CaP treatments. Digestibility of NDF was higher in CaP-prilled compared to control ($P < 0.06$), CaCO₃ ($P < 0.09$), and CaP-powder ($P < 0.05$) treatments. Total VFA production in ruminal cultures was increased ($P < 0.05$) by supplemental Ca. In response to Ca source, total VFA production was higher for CaP-prilled than CaCO₃ ($P < 0.01$) and CaP-powder ($P < 0.08$) treatments. Propionate production and molar proportion were higher ($P < 0.01$) in CaP than control or CaCO₃ treatments. Butyrate production was higher ($P < 0.01$) for CaP-prilled and CaCO₃ treatments compared to control and CaP-powder treatments. Molar proportion of butyrate was higher ($P < 0.01$) for CaCO₃ than the other treatments. Production and molar proportion of isovalerate was lower ($P < 0.01$) for CaP-powder compared to other treatments. These results indicate that both dietary Ca level and source affect soluble Ca concentrations and fermentation in continuous cultures of ruminal microorganisms.

Key Words: Microbial Fermentation, Calcium

Ruminant Nutrition: Dairy - Feedstuffs

943 Impact of feeding high free fatty acid whole cottonseed on milk yield and composition. J. K. Bernard^{*1}, J. Siciliano-Jones², and T. C. Wedegaertner³, 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 off quality. Limited data are available on the feeding value of off-quality WCS. Approximately 300 lactating Holstein cows were used in a 3 x 3 Latin square trial to determine the impact of feeding whole cottonseed

with different concentrations of free fatty acids in the oil. Cows were assigned to each pen by parity, DIM, and milk yield. Treatments included WCS with low (10.7% FFA, L), high (35.5% FFA, H) or a 50:50 blend of H and L (23.1 % FFA, M). During each 3-wk experimental period, pen intake was recorded daily, milk weights were recorded at each milking (3X) and milk samples were collected from each milking once weekly for analysis of milk fat, protein, and milk urea nitrogen (MUN). Dry matter intake and milk yield was similar for all treatments: 27.5 and 40.1; 27.4 and 40.2; and 27.7 kg/d and 39.9 kg/d for L, M, and H respectively. Milk fat concentration ($P < 0.001$) and yield ($P < 0.002$) were lower for cows fed H compared with L and M: 3.02 and 1.21; 3.13 and 1.26; and 2.87 % and 1.14 kg/d for L, M, and H, respectively. No differences were observed in concentration or yield of milk protein among treatments (average of 2.97% and 1.18 kg/d). Yield of energy corrected milk (ECM) was lowest ($P < 0.003$) for H reflecting the lower yield of milk fat (37.0, 37.6, and 36.0 kg/d for L, M, and H, respectively). Concentrations of MUN were lowest for L and highest for H ($P < 0.003$): 12.97, 13.12, and 13.42 mg/dl for L, M, and H respectively. The reduced milk fat and increased MUN suggest changes in ruminal fermentation, but the changes were not great enough to alter intake, milk yield, or milk protein synthesis.

Key Words: Whole Cottonseed, Milk Yield, Milk Composition

944 Utilisation of whole-crop pea silage in dairy cow rations as a potential protein source to replace soya bean meal. K. J. Hart*, R. G. Wilkinson, L. A. Sinclair, and J. A. Huntington, *Harper Adams University College, Newport, Shropshire, UK.*

The use of protein concentrates in ruminant diets is both essential and costly. With the consumer demand in the UK for high quality, low cost products, there is a need for a cheap and efficient protein source for inclusion into ruminant rations. Whole-crop pea (WCP) silage has the potential to fulfil this role, being a cheap and easy to grow crop, which can also be used in organic systems. In addition, the presence of condensed tannin in coloured flowered varieties of peas may confer protection of protein in the rumen. The aim of this experiment was to evaluate WCP silage as a replacement for soya bean meal. WCP silage was produced from a spring-sown crop (cv.Racer) which was cut after 13 weeks, wilted and ensiled with a bacterial inoculant. The three diets were ad lib grass silage (GS) and fermented whole-crop wheat (WCW, 50:50) with 8kg of soya based concentrate (GWS), or ad lib GS; WCW and WCP (25:25:50) with either 8kg/day soya based concentrate (PS) or 8kg wheat based concentrate (soya replaced with wheat, PW). Diets were offered to 9 pregnant Holstein-Friesian in late lactation in a latin rectangle design, with each period lasting 28 days. Intakes and performance traits were recorded over the last 7 days of each period. Silage dry matter intakes increased in cows fed diets containing WCP silage (12.0 vs 13.4 vs 13.0, s.e.d. 0.53 $P < 0.05$, GWS, PS and PW respectively) whilst concentrate dry matter intakes were similar across all treatments ($P > 0.05$). Milk yield did not vary significantly across the treatments (23.1 vs 23.8 vs 22.0, s.e.d. 0.86, $P > 0.05$, GWS, PS and PW respectively), although there was a significant increase of 0.08 kg/day in milk protein yield in cows fed PS (0.77 vs 0.85 vs 0.77, s.e.d. 0.032, $P < 0.05$, GWS, PS and PW respectively). Cows fed the control diet of GWS had higher nitrogen efficiency for milk production when compared to the diets containing WCP silage (27% vs 24% vs 24%, s.e.d. 0.01, $P = 0.01$). Results from this experiment suggest that 1kg DM of WCP silage can replace a daily portion of 1kg DM of soya bean meal. With WCP silage costing around 63/T DM, a considerable saving could be achieved

Key Words: Pea Silage, Dairy Nutrition

945 Replacement of blood meal with a supplement containing bacterial and fungal fermentation extracts in diets fed to mid-lactation dairy cows. C. S. Ballard*¹, P. Mandebvu¹, M. P. Carter¹, K. W. Cotanch¹, R. J. Grant¹, C. J. Sniffen², W. Rodee³, and L. Robinson³, ¹*W.H. Miner Agricultural Research Institute, Chazy, NY*, ²*Fencrest LLC Holderness, NH*, ³*Agriformulations, Inc., Waddington, NY.*

Lactational response to a commercial feed supplement containing bacteria and fungal fermentation extracts (Protein Edge[®]) in place of animal protein was measured using 40 primi- and multiparous midlactation (78 to 231 days in milk) Holstein cows in a crossover design study with two 28-d periods. Cows were blocked by parity and milk production and

assigned randomly to a control total mixed ration (TMR) containing blood meal (210 g/cow/day) and corn distillers grain (48 g/cow/day), or a TMR containing Protein Edge[®] (PE; 28 g/cow/day), soybean hulls (45 g/cow/day) and corn gluten meal (81 g/cow/day). In addition, the control TMR contained more Soy Pass compared with the PE TMR (810 vs. 163 g/cow/day). Diets were formulated such that the amounts of lysine and methionine in metabolizable protein in both TMR were close to the recommended levels of 7.2 and 2.2%, respectively, while maintaining a lysine to methionine ratio of approximately 3 to 1 (expressed as % of MP). The TMR contained 49% forages and 51% concentrates with 19% CP and 28% NDF. Milk production and composition from all cows was recorded during the fourth week of each period. Cows fed the control TMR containing blood meal and cows fed the TMR containing PE, respectively, produced 34.2 and 34.2 kg/d milk with 4.00 and 4.01% fat, 3.24 and 3.28% true protein, 4.72 and 4.69% lactose, 12.6 and 12.6 mg/dl milk urea N, and 281,000 and 223,000 somatic cell counts/ml, and 0.10 and 0.10 change in BCS per period ($P > 0.07$). In conclusion, when blood meal was replaced with PE and rations were reformulated to meet lysine and methionine, there were no differences in milk yield and milk composition by Holstein cows, showing that the PE product performed as well as blood meal when fed to supply similar concentrations of methionine and lysine posturally.

Key Words: Methionine and Lysine, Blood Meal, Dairy Cow

946 Replacement of alfalfa haylage with ensiled wet distillers grains and beet pulp in lactating dairy cows diets. A. D. Garcia*, K. F. Kalscheur, A. R. Hippen, and D. J. Schingoethe, *South Dakota State University, Brookings.*

Wet corn distillers grains (WDG) and wet beet pulp (WBP) are excellent feeds for ruminants. Energy in WDG is supplied by its high lipid and fermentable fiber content, whereas in WBP it results from highly fermentable carbohydrates. The objective of this research was to evaluate the effect on milk production of substituting alfalfa haylage with either one of two WDG/WBP blends. Nine cows (six Holstein and three Brown Swiss) with 92 ± 4 DIM were used in a 3×3 Latin square with 3-wk feeding periods. Experimental diets were: 1) control diet (C) which contained 17.2% DM alfalfa haylage; 2) treatment 1 (T1), where 21.7% DM of a 33% WDG and 66% WBP blend substituted for alfalfa haylage; and 3) treatment 2 (T2), where 24.5% DM of a 66% WDG and 33% WBP blend substituted for alfalfa haylage. All other feeds were maintained constant across treatments with the exception of dry DG, which was added at 10.2, 5.7, and 0% of the diet DM in C, T1, and T2, respectively, to balance for dietary CP. Diets were balanced for 16% CP, 20% ADF, 30% NDF, and 1.60 Mcal NEL/kg. Dry matter intake did not differ between treatments ($P > 0.10$). Feed efficiency tended to increase ($P < 0.07$) in cows fed T1 when compared to C. Cows fed T1 and T2 produced more milk (38.0 and 39.2 vs 35.7 kg/d; $P < 0.06$) when compared to C. Although cows fed C tended to have higher milk protein percentage ($P < 0.07$), milk protein yields were higher (1.2 and 1.3 vs. 1.1 kg/d; $P < 0.05$) for cows fed T1 and T2. Milk fat percentage decreased for cows fed T1 and T2 compared to C (3.1 vs. 3.6%; $P < 0.01$), however milk fat yield did not differ across treatments ($P > 0.10$). Results from this experiment suggest that blends of WDG and WBP can substitute for alfalfa haylage in dairy cow diets while improving total milk production and milk protein yield.

Key Words: Wet Beet Pulp, Wet Distillers Grains, Dairy Cows

947 Increasing wet distillers grains in the diets of dairy cows on milk production and nutrient utilization. K. F. Kalscheur*, A. L. Justin, A. R. Hippen, and D. J. Schingoethe, *South Dakota State University, Brookings.*

The objective of this experiment was to determine lactation performance and nutrient utilization in dairy cows fed increasing concentrations of wet corn distillers grains (WDG). Four ruminally cannulated multiparous Holstein cows averaging 117 DIM were used in a 4×4 Latin square design with 4-wk periods. Wet distillers grains were included at 10, 20, 30, or 40% of the diet DM. The forage portion of the diets was constant and consisted of 30% corn silage and 15% bromegrass hay (DM basis). Soybean meal, soybean hulls, and animal fat were replaced by WDG as inclusion rates increased. Diets (DM basis) averaged 17.8% CP, 41.7% NDF, 22% ADF, 6.5% EE, and 1.65 Mcal/kg. Diet DM decreased (49.5, 45.8, 41.9, and 40.4% for 10, 20, 30, and 40% WDG, respectively) as diet WDG increased. Dry matter intakes decreased (P

< 0.02) as diet WDG increased in the diets (25.7, 24.6, 22.0, and 18.4 kg/d). Milk production decreased (40.1, 36.7, 34.9, and 34.8 kg/d; $P < 0.01$) as WDG increased from 10 to 40% of the diet. Milk fat percentage (2.64, 2.96, 2.93, and 2.64%; $P < 0.03$) and milk protein percentage (3.21, 3.24, 3.15, and 3.34%; $P < 0.06$) responded quadratically as WDG increased. Milk component yield and MUN did not differ across diets. Total tract digestibilities of DM, OM, ADF, and NDF did not differ ($P > 0.10$) with increasing levels of WDG. Total tract digestibility of CP increased (59.5, 64.7, 67.7, and 67.3%; $P < 0.03$) with increased WDG in the diet. Nitrogen intake (691, 708, 645, 534 g/d) tended to decrease ($P < 0.09$) due to the decrease in DMI. As a result, the response of N efficiency to the addition of WDG in the diets tended to be quadratic (28.0, 25.0, 26.9, 34.2%; $P = 0.10$). As WDG increased in the diets, calculated fecal N decreased ($P < 0.01$), but urinary N was not different. Nutrient digestibilities of the diets with the exception of CP were unchanged across diets. Milk production decreased when WDG was added to the diet above 10% of the dry matter.

Key Words: Wet Distillers Grains, Nutrient Digestibility, Nitrogen Utilization

948 Dietary factors influencing milk protein content of cows fed grass silage-based diets. P. Huhtanen^{*1} and J. Nousiainen², ¹MTT Agrifood Research Finland, ²Valio Ltd, Valio, Finland.

Protein is the most valuable component of milk, and therefore there is an economical incentive to enhance milk protein content (MPC). A mixed model regression analysis was conducted to investigate the relationship between diet parameters and MPC(g/kg). Data consisted of 335 treatment means from 46 studies. Diets were based primarily on grass silage and concentrate supplements containing cereal grains and oilseed meals. Because part of CP is NPN, MPC values were corrected for urea (MPCc). Dietary parameters (g/kg DM) were CP, ether extract (EE), starch, non-structural CHO, lactic acid (LA), NDF, metabolizable protein (MP), protein balance in the rumen (PBV) and ME (MJ/kg DM). Single parameters poorly described the variation in MPC. MP was the best single predictor of MPC ($R^2=0.40$), and EE of MPCc ($R^2=0.23$). Increases in EE and LA had a negative effect on MPC and MPCc. The best equations based only nutrient concentrations were: $MPC=23.9-0.045EE-0.007LA+0.117MP-0.005PBV$ ($R^2=0.63$; $SE=0.44$) and $MPCc=24.2-0.042EE-0.007LA+0.105MP-0.017PBV$ ($R^2=0.61$; $SE=0.45$). Single intake parameters (total DMI, ME and MP intake) explained 62-69 and 56-68% of the variation in MPC and MPCc, respectively. Bivariate models including CP or PBV, in addition to one intake parameter, suggested that a large proportion of increased MPC in response to higher dietary CP concentration was due to increased milk urea. Carbohydrate composition of the diet had few significant effects on MPC, when variation in ME of MP intake was excluded. The best predictive models included: $MPC=24.0+0.018MEI-0.051EE-0.007LA+0.075MP$ ($R^2=0.76$; $SE=0.39$), and $MPCc=26.0+0.022MEI-0.058EE-0.008LA+0.039MP$ ($R^2=0.74$; $SE=0.40$), respectively. Lower MPC with increased EE resulted primarily from dilution. The effect of LA is related to the lower energy supply of silage fermentation acids than carbohydrates for rumen microbes. It is concluded that milk protein content was largely related to energy and MP intake. At a constant ME intake, MPC can be increased by avoiding excessive amounts of fat, restricting in-silo fermentation and increasing MP content.

Key Words: Grass Silage, Milk Protein

949 Effects of NDF from alfalfa hay, grass hay, straw, and whole cottonseed on performance of lactating cows. P. B. Bucci*, M. L. Eastridge, and C. V. D. M. Ribeiro, *The Ohio State University, Columbus.*

Straw is used in some rations in the field for lactating dairy cows as a source of effective fiber; however, limited data are available on using straw versus legume or grass hay on an equivalent forage NDF basis. Four ruminally cannulated multiparous Holstein cows (276 DIM) were used in a 4 x 4 Latin square design, with the following diets fed ad libitum: 1) 17% forage NDF (FNDF) from corn silage (CS) and alfalfa hay (11.7% of DM), 2) 17% FNDF from CS and grass hay (7.0% of DM),

3) 17% FNDF from CS and wheat straw (5.2% of DM), and 4) 12.8% FNDF from CS with 10% whole, linted cottonseed (WCS) in the diet. Corn silage was held constant at 35.7% of the diet. Periods were 21 d, with the last 10 d used for animal performance data. Cows were milked twice daily, and four consecutive milkings per week were sampled for analyses of milk components. Rumen samples for VFA and pH were taken at 6 h post-feeding on d 19 and 20 of each period. The DM intake was similar among treatments (24.7 kg/d), but milk yield was lower for straw than grass and WCS (22.7, 23.5, 21.6, and 24.0 kg/d for alfalfa hay, grass hay, straw, and WCS, respectively). Yields of fat and protein and concentrations of fat (4.28%), protein (3.54%), and urea nitrogen (14.46 mg/dl) in milk did not differ among treatments. Rumen pH was similar among treatments at 6.25. Ruminal proportion of acetate was lower and propionate higher for WCS. The three sources of forage NDF appeared to result in similar ruminal conditions. Data are not available yet to explain the lower milk yield with the straw. Although WCS lowered the acetate:propionate ratio, ruminal pH remained adequate and milk fat percentage was not depressed.

Key Words: Forage NDF, Whole Cottonseed, Straw

950 Rumen fill and intake regulation of grazing dairy cows under continuous stocking. H. Z. H. Taweel*, B. M. Tas, J. Dijkstra, and S. Tamminga, *Department of Animal Sciences, Animal Nutrition Group, Wageningen University, Wageningen, The Netherlands.*

This experiment aimed at studying the possible role of rumen fill in signalling the termination of the three main grazing bouts of dairy cows. For this purpose the day was divided into three main periods (6:00-12:00 h, 12:00-18:00 h and 18:00-24:00 h) where the three main grazing bouts (dawn, afternoon and dusk) of dairy cows usually occur. Four rumen-cannulated dairy cows were used in a repeated measures design, with time of day as the within subjects factor. The cows had access to a 1-ha grass sward under a continuous stocking system. To estimate rumen pool sizes, dry matter intake (DMI), eating time (ET), bite rate (BR), bite mass (BM) and intake rate at the three bouts, cows were rumen-evacuated at 6:00, 12:00, 18:00 and 24:00 h and jaw recorders were fitted to the cows between these time points. To estimate clearance rate (Kcl) cows were deprived of food from 24:00 till 8:00 h next morning, when rumen evacuations were performed again. Rumen pool sizes were larger ($P < 0.01$) at 24:00 h compared to other times of the day (9.5 vs 13.5 kg DM). Because rumen evacuations in the present study were performed at fixed time points during the day and not immediately when grazing ceased, it was important to estimate the fluctuation in rumen fill between the measured points if we want to draw valid conclusions concerning its role in regulating the cessation of grazing. To estimate rumen fill fluctuation during the day, a dynamic model was constructed based on the measured ET, BR, BM, and Kcl. The model consisted of one state variable, which was the rumen NDF pool (QNDF). QNDF receives input from feed intake and its output is disappearance from the rumen through Kcl. Despite the fact that cows grazed 132 min and 175 min during the morning and afternoon grazing bouts, respectively, QNDF did not reach the value it reached at 24:00 h. This indicates that dairy cows interrupted these two grazing bouts long before reaching their maximal rumen fill capacity. However, rumen pool sizes were always maximal at the time when the dusk grazing bout ceased indicating that rumen fill is more likely to play a major role in signaling the termination of the dusk grazing bout.

Key Words: Rumen Fill, Intake, Grazing

951 Corn grain endosperm type and brown midrib 3 corn silage: site of nutrient digestion and ruminal digestion kinetics in lactating dairy cows. C. C. Taylor* and M. S. Allen, *Michigan State University, East Lansing.*

Effects of corn grain endosperm type and the brown midrib 3 mutation in corn silage on site of nutrient digestion and ruminal digestion kinetics in cows were evaluated. Eight ruminally and duodenally cannulated Holstein cows (72 ± 8 DIM; mean \pm SD) were used in a duplicated 4x4 Latin square design with a 2x2 factorial arrangement of treatments. Grain treatments were dry corn grain from hybrids with floury

or vitreous endosperm; silage treatments were corn silage from a hybrid with the *bm3* mutation or its isogenic control hybrid without the *bm3* mutation. Diets contained 26% neutral detergent fiber and 17% crude protein. Treatment corn grain and silage supplied 23% and 38% of the diet DM, respectively. Interactions of main treatment effects did not occur for any measures of nutrient digestibility. Floury endosperm grain increased total tract OM digestibility versus vitreous grain (75.2 vs. 71.9%; $P < 0.01$) primarily by increasing starch digestibility. Floury grain increased apparent ruminal starch digestibility (57.0 vs. 35.0%; $P < 0.01$) compared to vitreous grain because of a 70% increase in starch digestion rate (21.9 vs. 12.9%/h; $P < 0.01$) and a tendency for decreased ruminal starch passage rate (16.2 vs. 21.2%/h; $P < 0.10$). Post-ruminal starch digestibility (% of intake) was 39.3 and 56.8% ($P < 0.03$) for floury and vitreous grain, respectively, but as a % of duodenal flow, floury grain was more digestible than vitreous grain (90.8 vs. 83.6%; $P < 0.01$). Although substantial compensatory post-ruminal starch digestion occurred for vitreous diets, replacing vitreous grain with floury grain increased total tract starch digestibility from 91.7 to 96.3% ($P < 0.001$). Brown midrib corn silage increased total tract NDF digestibility compared to control silage (51.1 vs. 45.8%; $P < 0.02$) by numerically increasing ruminal and post-ruminal NDF digestibility, but digestion and passage rates of potentially digestible NDF did not differ across treatments. Endosperm type of corn grain can affect site and extent of starch digestion.

Key Words: Endosperm, Brown Midrib, Digestion

952 Effects of physically effective NDF on chewing activity and rumen pH of dairy cows fed diets based on barley silage. K. A. Beauchemin* and W. Z. Yang, *Research Center, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada.*

A study was conducted to investigate the effects of physically effective (pe) NDF content of dairy cow diets on chewing activity and rumen pH. The study was designed as a double 3 x 3 Latin square using six lactating dairy cows with ruminal cannulas. Three levels of dietary peNDF (high, medium and low) were compared. The diets contained whole crop barley silages prepared with two theoretical lengths of cut (TLC): coarse (3/8") and fine (3/16"). The high, medium and low peNDF diets were formulated using coarse silage, equal proportions of coarse and fine silages, or fine barley silage, respectively. The peNDF content of the diets was determined as the proportion of the TMR (as-fed) retained on the 0.75" and 0.31" screens of the Penn State Particle Separator multiplied by dietary NDF content (DM basis). The peNDF contents were 13.8, 11.8 and 10.5% (DM basis) for the high, medium and low diet, respectively. Increasing peNDF content of diet had no effect on eating time (280, 247 and 267 min/d for high, medium and low, respectively) but quadratically increased ($P < 0.05$) ruminating time (440, 465 and 363 min/d for high, medium and low, respectively) and total chewing time (720, 712 and 630 min/d for high, medium and low, respectively). Mean pH, area under the pH curve, and duration of pH < 5.8 or < 5.5 were not affected by the peNDF content of diets. Unexpectedly, the peNDF content of the diet and ruminating time were negatively correlated to mean rumen pH ($r = -0.42$; $P < 0.15$) but positively correlated to the time during which pH was below 5.5 ($r = 0.40$, $P < 0.15$), an indicator of rumen acidosis. The results suggest that increasing the peNDF content of the diet can increase chewing activity which reduces the risk of acidosis. Dairy cows fed barley silage as the predominant forage source require a minimum dietary peNDF of 12% of DM.

Key Words: Physically Effective NDF, Chewing, Rumen pH

953 Effect of barley and its amylopectin content on ruminal fermentation and nitrogen utilization in lactating dairy cows. A. E. Foley*¹, A. N. Hristov¹, A. Melgar¹, J. K. Ropp¹, R. P. Etter¹, C. W. Hunt¹, and K. Huber², ¹*Department of Animal and Veterinary Science, University of Idaho, Moscow,* ²*Department of Food Science and Toxicology, University of Idaho, Moscow.*

The objective of this study was to evaluate the effect of partial substitution of corn grain by either normal or high-amylopectin (waxy) barley on ruminal fermentation, digestibility of nutrients, nitrogen (N) losses, and ammonia utilization in lactating dairy cows. Six late-lactation ruminally and duodenally cannulated Holstein cows were allocated to dietary

treatments in a replicated 3 x 3 Latin square design. Diets contained (DM basis): 40% corn grain (C), 30% normal barley and 10% corn (B), and 30% waxy barley and 10% corn (WB). All grains were steam-rolled. Barley grain had a greater rate of in situ ruminal DM degradability than either waxy barley ($P < 0.05$) or corn grain (trend at $P = 0.105$). Rumen pH and VFA concentrations were not different ($P > 0.05$) between treatments, but ammonia and acetate concentrations were less ($P < 0.05$) in C compared to B and WB. Microbial protein synthesis (MPS) and efficiency were not affected ($P > 0.05$) by treatment. Rumen and total tract N digestibility were reduced ($P < 0.05$) in C compared to B. Diet B resulted in the greatest ($P < 0.05$) N intake, and total N loss was greater ($P < 0.05$) in WB than in B. Plasma urea N concentration was not different ($P > 0.05$) among diets, but milk urea N (MUN) was greater ($P < 0.05$) in B and WB compared to C. Rumen ammonia (labeled with ¹⁵N) utilization for MPS or milk protein was not affected ($P > 0.05$) by treatment. Tracer excretion in milk protein was greater ($P < 0.05$) in C compared to WB. Milk yield and composition were not affected ($P > 0.05$) by treatment. Rumen ammonia and MUN concentrations suggested less efficient utilization of dietary N in B than in C, but overall, N losses were not affected by grain type. Inclusion of WB in the diet resulted in increased N losses compared to B and reduced efficiency of utilization of ruminal ammonia for milk protein synthesis compared to C.

Key Words: Barley, Corn, Dairy Cow

954 A nutritional evaluation of assiniboia oat, baler oat, and rosier barley silage for dairy cattle. T. L. Heck*, D. A. Christensen, J. J. McKinnon, and P. Yu, *Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK, Canada.*

Three studies were conducted to evaluate the nutritional value of oat silage (*Avena sativa*) for use in dairy cattle rations. A total tract digestibility study using 18 lambs in a complete random design was conducted to determine the digestibility of dry matter (DM), organic matter (OM), crude protein (CP), crude fat (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) of Assiniboia (ASS) and Baler (BAL) oat silage compared to Rosier (ROS) barley silage. An *in situ* study was conducted using a non-lactating fistulated cow to determine rumen kinetic parameters of carbohydrate fractions. A dairy production trial was carried out using 9 lactating Holsteins at 90±20 DIM averaging 43 kg/d milk yield in a triple 3x3 Latin square design to determine the effect on milk yield and composition when fed 48% of ASS, BAL, and ROS silage (DM) in a total mixed ration (TMR). Lamb voluntary intake was higher ($P < 0.05$) for ROS compared to the two oat varieties, however BAL was higher than ($P < 0.05$) ASS. Digestibility of DM and OM were significantly different across treatments (DM 71.8, 65.2, 60.9, OM 73.9, 66.9, 63.3 for ROS, ASS, and BAL, respectively). CP digestibility was greater ($P < 0.05$) for ROS compared to the oat varieties. The digestibility of NDF, ADF, and ADL, and EE were similar between ROS and ASS treatments and both were higher ($P < 0.05$) than BAL. Dairy DM intake was similar across all dietary treatments. Milk yield was similar for ASS and BAL (41.6 kg/d), and 6% lower ($P < 0.05$) than ROS. Milk fat percentage was greater ($P < 0.05$) for ASS and BAL compared to ROS, which resulted in similar milk fat yields and 3.5% fat corrected milk among treatments. Milk protein yield and percentage were higher ($P < 0.05$) for ROS compared to ASS and BAL. It was concluded that oat silage could be substituted for barley silage as a forage source for dairy cattle rations.

Key Words: Silage, Dairy, Digestibility

955 Lactation performance and milk fatty acid profile of dairy goats fed four different forage species. A. Doyon*¹, G. F. Tremblay², and P. Y. Chouinard¹, ¹*Universite Laval, Quebec, QC, Canada,* ²*Agriculture and Agri-Food Canada, Quebec, QC, Canada.*

Forages provide substantial lipids in ruminant diets, and more than 50% of total fatty acids in certain forage species are C18:3. Our objective was to evaluate the effect of feeding four different forages on milk production and composition in dairy goats. Two grass [timothy (*Phleum pratense*), Italian ryegrass (*Lolium multiflorum*)] and 2 legume [alfalfa (*Medicago sativa*), white clover (*Trifolium repens*)] forages were harvested as silage. The C18:3 concentration in those forages was 8.8, 18.6,

7.8, and 9.8 mg/g DM, respectively. Twelve dairy goats of 3 different breeds (4 Alpine, 4 Saanen, and 4 Toggenbourg) that averaged 216 days in milk were used in a replicated 4 x 4 Latin square arrangement with 21-d periods. Goats were offered ad libitum access to a basal diet consisting of timothy, ryegrass, alfalfa, or white clover silage, supplemented with 180 g/d of a blend of rolled barley (65%), Topsoy[®] (22%), molasses (2%), and vitamin and mineral mix (11%). Milk yield and milk protein content were decreased, and fat content was increased with timothy as compared with ryegrass, alfalfa, and white clover ($P < 0.01$). Milk fat yield was not affected by forage type. Feeding grass forages decreased ($P < 0.01$) the proportion (% by weight) of C10:0, C12:0, C14:0, and C16:0, and increased the proportion of C18:0 and *cis*-9 C18:1 in milk fat as compared with legume forages. The C18:3 concentration was higher for alfalfa (1.68%), intermediate for ryegrass (1.59%) and white clover (1.60%), and lower for timothy (0.91%) ($P < 0.01$). Concentration of *cis*-9, *trans*-11 C18:2 was higher for ryegrass and alfalfa (0.47 and 0.45%, respectively), and lower for timothy and white clover (0.36 and 0.33%, respectively) ($P < 0.01$). The concentration of *trans*-11 C18:1 was higher for ryegrass (0.88%), intermediate for timothy (0.71%) and alfalfa (0.73%), and lower for white clover (0.53%) ($P < 0.01$). The concentration of *cis*-9, *trans*-11, *cis*-15 C18:3 was higher with ryegrass (0.048%) as compared with timothy, alfalfa, and white clover (0.009, 0.012, and 0.013%, respectively) ($P < 0.01$). The fatty acid profile of milk fat can be modified by feeding different forage species to dairy goats.

Key Words: Conjugated Linolenic Acid, Omega-3 Fatty Acid

956 Effects of feeding flaxseed on fatty acid composition in milk and cheese in dairy ewes. R. Zhang*, A. F. Mustafa, and X. Zhao, *McGill University, Ste-Anne-De-Bellevue, QC, Canada.*

A study was conducted to determine the effects of feeding various levels of flaxseed to lactating ewes on milk fatty acid composition, cheese yield and cheese fatty acid composition. One hundred and twenty lactating ewes (Suffolk East Friesian) were divided into 4 groups and were randomly assigned to one of 4 different isonitrogenous concentrates. The concentrates contained 0% (C1), 8% (C2), 12% (C3) and 16% (C4) flaxseed. The EE content (DM basis) of the concentrates was 3.2, 5.4, 7.4 and 9.4%, respectively. All animals were fed 1 kg of concentrate each plus ad-libitum intake of alfalfa hay. Animals were fed in pens. Results showed flaxseed supplementation had no effect on milk protein, lactose and casein percentages. However, milk fat percentage was higher ($P < 0.05$) for ewes fed C3 and C4 than for those fed C1 and C2. Cheese yield was 12% higher for ewes fed C3 than for those fed C1. However, flaxseed supplementation had no effect on cheese fat or protein percentage. Flaxseed supplementation linearly decreased ($P < 0.05$) the concentrations of medium chain and saturated fatty acids and increased ($P < 0.05$) those of long chain, mono- and poly-unsaturated fatty acids. Conjugated linoleic acid (CLA) and omega-3 fatty acid in milk and cheese were linearly increased ($P < 0.01$) as a results of flaxseed supplementation. Feeding C4 increased CLA and omega-3 fatty acids of milk by 66 and 75%, respectively. The corresponding increases in cheese were 67 and 74%, respectively. It was concluded that feeding flaxseed to dairy ewes can increase health-promoting fatty acids without major changes in milk fat or protein percentages

Key Words: Dairy Ewe, Fatty Acids, Cheese