each pit. One pit served as the control and the other pit was amended with approximately 1.5 and 3.0 g of thymol/L in experiment 1 and 2, respectively. Each experiment lasted 18 d, during which time five to six 200 ml samples were withdrawn from underneath each pen and analyzed for DM, thymol, VFA, and coliform bacteria. At the end of each experiment, 50 g samples, 6 from each pit, were placed in 200 ml serum bottles and gas volume and composition were determined periodically for 28 d. The slurry DM was not affected by thymol treatment in either experiment. Compared to the control pit, VFA production was reduced 1.28 and 1.71 mmoles/L d^{-1} (65 and 100%) for thymol amendments of 1.5 and 3.0 g/L, respectively ($P < 0.01$). Coliform and *Escherichia coli* viable cells were reduced 1.55 and 1.76 $\log_{10}$ CFU/g slurry for the 1.5 g of thymol/L treatment, respectively; and 2.73 and 2.94 $\log_{10}$ CFU/g slurry for the 3.0 g of thymol/L treatment, respectively. Total gas production from the serum bottles was reduced 64 and 76% for thymol amendments of 1.5 and 3.0 g/L, respectively ($P < 0.01$); and methane production was reduced 77 and 93%, respectively ($P < 0.01$). These results suggest that thymol may be useful in swine production facilities equipped with slotted floor manure pits to reduce pathogens, odor, and greenhouse gas.

Key Words: Swine manure, Odor, Pathogens

Ruminant Nutrition: Fat Feeding, Metabolism & Composition

402 Artificial neural networks to model the rumen fermentation pattern in dairy cattle. M. Craninx, B. Vlaeminck, and V. Fievez*, *Ghent University*, *Melle, Belgium*.

The aim of this study is a preliminary evaluation of the use of an artificial neural network (ANN) to predict rumen molar proportions of volatile fatty acids from milk fatty acids. The current study combined data from ten experiments with rumen fistulated dairy cows, resulting in a dataset of 138 observations, which were split into a training (n=93), a validation (n=10) and a test (n=35) set, with the former used to iteratively train the model until the minimal mean square prediction error of the validation set was reached and the latter to independently test the model. A similar distribution of the input and output variables in both data sets was ensured. Essential data-input pre-processing prior to ANN model development included normalisation in the [-1 1] interval and reduction of the number of variables by selecting mutual uncorrelated milk fatty acids, based on correlation and principal component analysis and by excluding milk fatty acids of dietary (e.g. C18:2n-6 and C18:3n-3) or multiple origin (e.g. cis 9 C18:1), based on background physiological knowledge. Different types of ANN architecture and training algorithms were evaluated and the final neural network was characterised by 1 hidden layer with 12 neurons and a Scaled Conjugate Gradient training algorithm. The selected input variables included the milk odd and branched-chain fatty acids, which are directly derived from rumen microbes and biohydrogenation intermediates, which accumulate to a different extent according to rumen conditions. The regression between the observed and predicted values showed similar results for training and test data, suggesting no overfitting. The evaluation on the test data showed determination coefficients of 0.801, 0.686 and 0.541 and a relative root mean square prediction error of 2.64%, 9.47 % and 8.64% of the observed mean for acetate, propionate and butyrate, respectively. The results suggest that ANN is a potential method to predict molar proportions of volatile fatty acids in the rumen.

Key Words: Modelling, Rumen fermentation, Milk fatty acids

403 ^{13}C Enrichment of conjugated linoleic acids and other fatty acids in cultures of ruminal microorganisms dosed with a stable isotope of linoleic acid. C. Thompson, J. Mulz, M. Reynolds, E. Thies, and T. Jenkins*, *Clemson University*, *Clemson, SC*.

Most published accounts of linoleic acid biohydrogenation by ruminal microorganisms account for only a single C18:2 intermediate, namely the *cis*-9, *trans*-11 conjugated linoleic acid (CLA) isomer, prior to its complete hydrogenation to stearic acid. The purpose of this study was to determine the full range of C18:2 intermediates arising from the biohydrogenation of linoleic acid. Six rumen in vitro cultures were run, with half of the cultures receiving 25 mg of unlabelled linoleic acid in 1 mL of ethanol and the other half receiving 25 mg U-^{13}C-linoleic acid in ethanol injected at the start of incubation. Samples were taken from each flask at 0, 6, 24, and 48 hours. Methyl esters of fatty acids were separated on a 100-m CP-Sil 88 column and abundances of the quasimolecular ion (M) and M+18 ion were determined by mass spectroscopy in positive chemical ionization mode. Enrichment (M+18/M minus background) data greater than zero were determined by t-test when $P > 0.05$, and time effects were analyzed by ANOVA. Enrichment of linoleic acid in the culture contents at 0 h was 0.32, which increased to 1.29 ($P < 0.05$) by 48 h. Enrichments at 48 h were 0.06, 0.08 and 0.22 for stearic acid, *trans*-11 C18:1, and *cis*-9, *trans*-11 CLA, respectively. Higher enrichments were observed for the *trans*-10, *cis*-12 CLA (1.33) and *trans*-9, *trans*-11 CLA (1.12) isomers by 48 h. Two additional peaks in the CLA region were enriched (0.99 and 0.87) but not identified. The increasing enrichment of linoleic acid over time suggests preferential utilization of the unlabelled compound for biohydrogenation, which was consistent with low enrichment for stearic acid. High enrichments that increase over time, such as those seen for several CLA, might indicate conversion from the labeled linoleic acid via a nonenzymatic isomerization process.

This project was supported by National Research Initiative Competitive Grant no. 2005-35206-15426 from the USDA Cooperative State Research, Education, and Extension Service.

Key Words: Biohydrogenation, Linoleic acid, Rumen

404 The effect of fish oil supplementation on ruminal C18 PUFA metabolism in beef steers offered either grass or red clover silage. M. R. F. Lee*[1], K. J. Shingfield[2], and N. D. Scollan[1], [1]*Institute of Grassland and Environmental Research*, *Aberystwyth, Ceredigion, UK*, [2]*MTT Agrifood Research*, *Jokioinen, Finland*.

Red clover and fish oil have been shown to alter ruminal lipid metabolism increasing PUFA and conjugated linoleic acid (CLA), respectively, in ruminant products. This study investigated the additive effect of these two feeds on C18 PUFA metabolism in beef steers. Eight Hereford × Friesian steers prepared with rumen and duodenal cannulae were offered either grass or red clover silage at 90% ad libitum with one of three levels of fish oil 0, 1, 2, or 3 % DMI. The experimental design consisted of four 2 × 2 Latin squares within each

oil level with an extra period. Flows of fatty acids at the duodenum were assessed using the dual phase-indigestible-marker technique. DMI was significantly ($P < 0.001$) higher for red clover silage (5.98) than grass silage (5.09 kg/d). Oil level had no effect on DMI with the exception of red clover at 3% oil which was significantly ($P < 0.01$) lower. C18:2 n-6 and C18:3 n-3 intakes averaged 13.2 and 25.1 for grass silage and 17.9 and 36.2 g/d for red clover silage, respectively. Biohydrogenation of C18:2 n-6 and C18:3 n-3 were significantly lower ($P < 0.001$) on red clover silage than grass silage with oil level increasing the extent of biohydrogenation in both diets ($P < 0.05$; 0.81 and 0.85 to 0.91 and 0.92 for grass silage and 0.76 and 0.73 to 0.87 and 0.83 for red clover silage at 0 and 3 % oil, respectively). C18:1 trans was significantly increased by oil level for both diets (4.6 to 15.0 and 9.4 to 22.5 for grass and red clover silage at 0 and 3 % oil, respectively). Oil level increased the proportion of C18:1 trans 11 in the duodenal digesta in both diets from 0.47 and 0.31 with no oil to 0.52 and 0.51 at 3 % oil for grass silage and red clover silage, respectively. CLA was also significantly increased on both diets by oil level (0.21 and 0.27 to 0.48 and 0.57 g/d for grass and red clover silage at 0 and 3 % oil, respectively). The results of this study show that red clover and fish oil have the potential to beneficially alter the fatty acid profile of ruminant products.

Key Words: Red clover, Fish oil, Biohydrogenation

405 Characterization of the acute lactation response to *trans*-10, *cis*-12 conjugated linoleic acid (CLA). K. J. Harvatine*, D. A. Dwyer, and D. E. Bauman, *Cornell University*, *Ithaca, NY*.

Trans-10, *cis*-12 CLA is a potent inhibitor of milk fat synthesis and the decrease in milk fat yield reaches a nadir after 4-5 d of abomasal infusion. Acute responses to *t*-10, *c*-12 CLA were evaluated using 4 cows in a cross-over design. Cows were milked with the aid of oxytocin every 4 h from d -1 to d 3 and every 6 h on d 4 relative to abomasal CLA infusion. An initial priming dose of 7.5 g of CLA was given at time-zero followed by steady state infusion of 2.5 g every 4 h for 3 d. Data were analyzed using a mixed model with repeated measures in time. Milk *t*-10, *c*-12 CLA concentration peaked at 6 h and reached steady state by 22 h. At termination of the infusion, the decrease in milk *t*-10, *c*-12 CLA concentration best fit a reciprocal-linear function with an average slope of 0.381 ($R2 > 0.98$, $P < 0.001$). Rate of milk synthesis was not affected by treatment. Milk fat percent decreased progressively after the priming dose, with the decrease being a trend at 6 h and significant by 10 h. Rate of milk fat synthesis also progressively decreased from time 0, with the decrease being a trend by 18 h and significant at 34 h. Yields of fatty acids > 16 carbons and de novo fatty acids decreased progressively from 0 h, were significant at 22 h and reached a nadir at 62 h. The milk fatty acid profile was initially unchanged, but about 14 h after the CLA dose was initiated, proportions of fatty acids began to progressively shift (increase in fatty acids > C16 and decrease in those < C16) and reached significance by 38-46 h. In contrast, changes in the desaturase indexes were immediate with a significant decrease by 6 h and a nadir by 14 h for most desaturase pairs. Thus, the desaturase enzyme must be more acutely responsive to *t*-10, *c*-12 CLA than other enzymes in milk fat synthesis. Overall, at the *t*-10, *c*-12 CLA dose utilized the initial decrease in milk fat synthesis involved an equal depression of short and long-chain fatty acid pathways and was followed thereafter by a more pronounced decrease in the synthesis of de novo fatty acids.

Key Words: *Trans*-10, *cis*-12 CLA, Milk fat depression

406 *Trans*-10, *cis*-12 conjugated linoleic acid reduces milk fat synthesis in lactating goats. M. Rovai*[1], A. L. Lock[2], T. A. Gipson[1], A. L. Goetsch[1], and D. E. Bauman[2], [1]*E (Kika) de la Garza American Institute for Goat Research*, *Langston, OK*, [2]*Cornell University*, *Ithaca, NY*.

The efficacy of *trans*-10, *cis*-12 conjugated linoleic acid (CLA) in reducing milk fat synthesis in dairy cows and sheep has been well documented. However, recent examinations of the effects of *trans*-10, *cis*-12 CLA on milk fat synthesis in lactating goats have proved inconclusive. The current study was therefore designed to determine if a lipid-encapsulated *trans*-10, *cis*-12 CLA supplement (LE-CLA; BASF AG, Ludwigshafen, Germany) would inhibit milk fat synthesis in lactating goats. Thirty multiparous Alpine dairy goats (50 ± 7.4 kg) in late lactation were randomly assigned in a 3 x 3 Latin square experiment. Goats were fed a bermuda grass hay, alfalfa pellet, concentrate diet (20:20:60) either A) unsupplemented (Control), B) supplemented with 30 g/d LE-CLA (low-dose; LLE), or C) supplemented with 60 g/d LE-CLA (high-dose; HLE). The LE-CLA supplement supplied 3 and 6 g/d of *trans*-10, *cis*-12 CLA for the LLE and HLE treatments, respectively. Treatment periods were 14 d in length with a 14 d washout interval. Milk yield, DMI, and milk protein content and yield were unaffected by treatment ($P > 0.05$). Compared with Control, milk fat yield was reduced 8.1% by the LLE treatment and 21.2% by the HLE treatment ($P < 0.001$), with milk fat content reduced 4.4 and 16.0% by the LLE and HLE treatments, respectively ($P < 0.001$). In conclusion, the results of the present study demonstrate that *trans*-10, *cis*-12 CLA reduces milk fat synthesis in lactating goats in a manner similar to that observed in lactating dairy cows and sheep. However, dose-response comparisons suggest that the degree of reduction in milk fat synthesis is less in goats compared with other lactating ruminant species studied. Further studies are required to verify and extend these results and to elucidate the mechanism of action for the effects observed with *trans*-10, *cis*-12 CLA supplementation.

Key Words: Goat, Milk fat, CLA

407 Comprehensive two-dimensional gas chromatography (GC×GC) for the analysis of fatty acids (FA) in milk. B. Vlaeminck*[1], J. Harynuk[2], K. Korkiasaari[3], V. Fievez[1], and P.J. Marriott[2], [1]*Ghent University*, *Belgium*, [2]*RMIT University*, *Australia*, [3]*University of Turku*, *Finland*.

GC×GC is a novel technique, rapidly gaining importance for the analysis of complex samples. Here we evaluate the potential of GC×GC for the analysis of the FA-profile of milk from dairy cows fed either a control diet or the control diet supplemented with marine algae. FA methyl esters were separated using a BPX80-column (30m×0.25mm×0.25µm) coupled to a BPX35 (0.25m×0.10mm×0.10µm). Modulation (6s) was performed using a LMCS II with liquid CO_2 as the cryogen. This modulator traps compounds eluting from the first dimension (^{1}D) column by means of a cold spot. By moving the modulator to a position upstream of the cold spot, the solutes are exposed to the oven temperature and are re-injected on the second dimension (^{2}D) column resulting in sharp peaks and higher sensitivity. The trap then returns to its original position and the process repeats throughout the analysis. Due to the difference in separation mechanism of the two columns, GC×GC results in an improved separation compared with analysis on the same column set without the use of the modulator (1-D GC). Thus whereas branched-chain C17-FA normally co-elute with C16:1-isomers using 1-D GC, GC×GC resulted in separation of these FA on the ^{2}D column.

Similarly, C18:1-isomers and conjugated linoleic acids were well resolved from C19:0 and C20:1-isomers, respectively. Displaying the peaks in a 2-D contour plot showed a well-ordered structure of FA according to their chemical properties, facilitating identification. ^{2}D retention times provided information on the number of double bonds whereas retention in the ^{1}D column was closely related with double bond position (n-3 vs. n-6). In conclusion, this experiment suggests GC×GC to be a powerful technique for the analysis of FA. Nevertheless, further research is needed to achieve improved separation of trans and cis C18:1-isomers, which may require a longer ^{1}D column.

Key Words: Comprehensive two-dimensional gas chromatography, Fatty acids

408 Whey protein gel composites of soybean and linseed oils used as a dietary method to modify the unsaturated fatty acid composition of milk lipids. J. M. Heguy*, S. O. Juchem, E. J. DePeters, M. Rosenberg, J. E. P. Santos, and S. J. Taylor, *University of California*, *Davis*.

Dairy products are an important source of nutrients in the Western diet. One criticism of milk fat relates to its low content of polyunsaturated fatty acids (PUFA) in particular the omega-3 fatty acids. Various methods to protect unsaturated fatty acids from rumen biohydrogenation have been developed. The most promising method employs formaldehyde, a carcinogen, and thus of limited use in the United States. A novel gel based on only whey protein, water, and oil (U.S. Patent Application 20040058003 A1 [Pending]; U.S. Patent Application 20050089550 A1 [Pending]) was developed at the University of California, Davis. The objective was to determine the efficacy a whey protein gel composite as a dietary method to increase the PUFA in milk lipids. Four primiparous Holstein cows were used in a 4x4 Latin square. The supplement lipid was a 1:1 (w:w) mixture of soybean:linseed oils (S/L) added to a total mixed ration. The S/L was fed in one of 4 chemical forms: (1) oil (O) where S/L was added directly to the diet unmodified, (2) calcium salts (CaS) of S/L, (3) whey protein concentrate (WPC) gel composite of S/L and (4) whey protein isolate (WPI) gel composite of S/L. Each diet provided a similar amount of total FA. Dietary treatment had no effect on dry matter intake, milk yield, and milk fat percentage. Milk triacylglycerol (TG) composition of linoleic acid averaged 2.77, 3.53, 3.59, and 6.35 g/100g fat and α-linolenic averaged 0.97, 1.33, 1.73, and 4.09 g/100g fat for O, CaS, WPC, and WPI. Total C18:1 *trans* FA decreased from 4.01 g/100g fat for O to 2.50 g/100 g fat for WPI. Similar changes in PUFA content of milk phospholipids were observed. The lower *trans* FA and higher PUFA in milk fat support a reduction in rumen biohydrogenation of PUFA. Feeding a whey protein gel composite successfully increased the PUFA of milk lipids.

Key Words: Unsaturated fatty acids, Milk fat, Whey protein gel

409 Feed intake, milk production and milk composition of dairy cows fed extruded linseed. M. C. Fuentes*[1], S. Calsamiglia[1], C. Sanchez[2], A. Gonzalez[3], J. E. Santos[4], J. R. Newbold[5], and J. Fontecha[6], [1]*Universidad Autonoma de Barcelona*, *Bellaterra, Spain*, [2]*Tauste Ganadera*, *Zaragoza, Spain*, [3]*Nutral, SA*, *Madrid, Spain*, [4]*University of California*, *Davis*, [5]*PROVIMI*, *Brussels, Belgium*, [6]*CSIC*, *Madrid, Spain*.

Four hundred early lactation multiparous Holstein cows were used in a randomised complete block design to determine the effects of extruded linseed on feed intake, milk yield and milk composition between weeks 4 and 20 of lactation. Forty of these cows were used to study the effects of extruded linseed on milk fatty acid (FA) profile and on individual feed intake. Cows were fed a 40:60 forage to concentrate ratio diet (17.7% CP, 27.7% FND and 6.03% EE) ad libitum that was identical in composition between treatments except for the treatment supplement that was control (CTR: 4.9% extruded soybean, 3.7% extruded corn, 1% calcium soaps and 0.02% Mepron) and linseed (LIN: 5.5% extruded linseed, 7.9% extruded corn, 4.1% extruded barley and 0.02% Mepron). Individual feed intake measured at 40 (23 kg DM) and 100 days in milk (24.2 kg DM) was not affected by treatment. Milk production (45 kg/d) was not affected by treatment, but the lower ($P<0.05$) milk fat percentage in cows fed LIN (2.65%) compared with CTR (2.86%) resulted in lower ($P<0.05$) fat-corrected milk yield for cows fed LIN (35.4 kg/d) compared with CTR (37.7 kg/d). Milk protein content was higher ($P<0.05$) in LIN (3.04%) than in CTR (3.00%). Total saturated FA were 4% lower ($P<0.05$) in milk fat from LIN cows compared with CTR cows (55.6 vs. 59.7 %) at 100 d of treatment. However, monounsaturated FA (35.7 vs. 33.3%) and polyunsaturated FA (8.6 vs. 6.8%) were 2.5% and 2% higher ($P<0.05$), respectively, in cows fed LIN compared with CTR cows. Linseed supplementation also increased ($P<0.05$) vaccenic acid, total CLA and n-3 FA (2.0, 1.5 and 1.7 fold, respectively). In general, linseed increased milk protein percentage, reduced milk fat percentage and enhanced the content of healthy FA in milk without modifying DM intake and milk yield.

Key Words: Linseed, Milk fatty acids, Milk production

410 Effects of dietary addition of unsaturated fat, vitamin E, and sorbitol on performance of dairy cows and fatty acid concentrations in milk. A. Todd*, M. L. Eastridge, C. V. D. M. Ribeiro, J. Engel, and B. Mathew, *The Ohio State University*, *Columbus*.

Dietary addition of soybean oil will increase conjugated linoleic acid (CLA) in milk but not to the extent that results from feeding fish oil. Data are limited on CLA in milk from feeding a combination of soybean and fish oils to provide different sources of fatty acids (FA). There is some evidence that increasing dietary concentration of vitamin E may affect milk CLA when feeding unsaturated fat. Sorbitol is being used in commercial feed, but limited published data are available. Eight lactating dairy cows (4 Holstein and 4 Jersey) were used in a Latin square design. Each period consisted of 3 wk, with wk 3 being used for data analyses. Rumen samples were taken from the Holstein cows (one with rumen cannula and via stomach tube for the other 3 cows). Diets consisted of 44% forage (80% corn silage and 20% alfalfa hay), were mixed once daily as TMR, and fed twice daily. The cows were fed 4 diets: 1) control diet (CNTL; 500 IU vitamin E), 2) 2% fish oil, 0.5% soybean oil, and 500 IU of vitamin E (FSO), 3) 2% fish oil, 0.5% soybean oil, and 2000 IU of vitamin E (FSOE), and 4) 1% sorbitol (SORB, dry form; 500 IU vitamin E). Diets with oil reduced DMI (18.8 versus 22.7 kg/d), but DMI was similar between CNTL and SORB. Milk yield (31.7 kg/d) and MUN (17.0 mg/dl) were similar among diets. Diets with oil reduced milk fat and protein percentages (3.87, 2.50, 2.58, and 3.96%; 3.38, 3.09, 3.16, and 3.32% for CNTL, FSO, FSOE, and SORB, respectively). Rumen VFA were similar among diets. Concentrations of vaccenic acid (3.49, 8.03, 11.8, and 1.96% of FA, respectively) and CLA (0.63, 1.28, 2.00, and 0.39%, respectively) in milk were increased with the diets containing oil; concentrations of vaccenic acid tended to be higher and CLA was higher for FSOE versus FSO. Both breeds responded similarly to the dietary treatments with respect to performance and individual milk FA. Addition of soybean and fish oils increased CLA in milk, but the

higher concentration of vitamin E in combination with the oils further increased milk CLA. Feeding the sorbitol resulted in similar responses as to feeding the CNTL diet.

Key Words: Fish oil, Sorbitol, Vitamin E

411 Effects of flaxseed processing on the recovery of A-linolenic acid in milk. G. Thangavelu*[1], M. Oba[1], M. Dehghan-banadaky[1], D. J. Ambrose[2], and E. Okine[1], [1]*University of Alberta*, *Edmonton, AB, Canada*, [2]*Alberta Agriculture Food and Rural Development*, *Edmonton, AB, Canada*.

Effects of flaxseed processing on the recovery of α-linolenic acid in milk were evaluated using ten primiparous Holstein cows (153 ± 30.7 DIM; mean±SD) in a crossover design with 14 d per period. We hypothesized that feeding unprocessed flaxseed is as effective as dry-rolled flaxseed at increasing α-linolenic acid concentration in milk fat. Experimental diets contained either whole (WH) or dry-rolled (DR) flaxseed at 10.1% of dietary DM. Dietary concentrations of NDF, CP, ether extract, and α-linolenic acid were 39.1, 17.6, 7.0, and 2.7%, respectively (DM basis). Dry matter intake, milk yield, and concentrations of milk fat, protein, and lactose were not affected by treatments, and averaged 17.5 kg/d, 27.5 kg/d, 3.60%, 3.00%, 4.73%, respectively. Apparent total tract digestibility of ether extract was lower for WH compared with DR (48.6 vs. 62.4 %; $P < 0.01$). Moreover, excretion of α-linolenic acid in feces was greater for WH compared with DR treatment (259 vs. 129 g/d; $P < 0.001$). However, α-linolenic acid concentration in milk was not affected by treatments (0.83 and 0.86 % for WH and DR, respectively), and both treatments had three times as much α-linolenic acid concentration as the period prior to the experiment (0.26%), during which sunflower seed was fed in place of flaxseed. These data indicate that both WH and DR treatments increased the absorption of α-linolenic acid to a similar extent despite the lower digestibility for WH treatment, which can be attributed to less lipolysis or fatty acid biohydrogenation for WH compared with DR. This speculation is supported by that WH treatment decreased concentration of vaccenic acid, a fatty acid intermediate during biohydrogenation, in milk fat compared with DR (1.9 vs. 3.0 %; $P < 0.01$). Dry-rolling flaxseed does not necessarily improve the absorption of α-linolenic acid probably because processing increases the extent of biohydrogenation in the rumen as well as digestibility.

Key Words: Flaxseed processing, α-linolenic acid, Biohydrogenation

412 The effect of bypass fat in the diet of dairy ewes on milk production. R. M. S. Emediato*, E. R. Siqueira, M. M. Stradiotto, S. A. Maestá, and A. Piccinin, *São Paulo State University*, *Botucatu, São Paulo, Brazil*.

Little is known in Brazil about milk production of ewes. As wool and meat production have become important activities in the country, an increasing interest in milk production is observed. Thus, the objective of the present work is to evaluate the effect of the use of bypass fat in the diet of Bergamasca dairy ewes on milk production. Eighty ewes were divided into 2 blocks according to parturition and age. Within each block, half of the animals received either one of two treatments: A – balanced diet (concentrate + corn silage) without bypass fat; and B – same diet as in A with added bypass fat (35g/ewe/day). In both blocks, the lambs were kept with their mothers in pasture during daytime and were separated at night. The lambs were returned to their mothers after the morning milking and were weaned at 45 days of age. The ewes were machine-milked starting 48 hours after parturition, once a day, at 7h A.M., for 60 days. Diets were isoenergetic and isonitrogenous, containing 22% CP and 66% TDN on a dry-matter basis. The statistical analysis was performed by means of SAEG 9.0 (System for Statistical and Genetic Analyses). Statistical differences were not observed ($P>.05$) between treatments for average daily milk production until 45 days; however, after 45 days, treatment B showed a higher ($P<.05$) milk yield in comparison to A (540 vs 502 g/ewe/day). This result may be attributed to the use of diet with bypass fat, which supposedly provided better absorption of unsaturated fatty acids in the small intestine.

Key Words: Unsaturated fatty acids, Dairy sheep, Milk yield

413 The effect of feed delivery time on dairy cattle production. C. J. Furedi*, A. D. Kennedy, and J. C. Plaizier, *University of Manitoba*, *Winnipeg, MB, Canada*.

Changing the delivery of fresh feed from the morning to the evening has shown improvement in average daily gain as well as in feed:gain ratio in beef cattle. This could be due to reduced heat stress in the summer and reduced cold stress in the winter with PM feeding. However, research in a thermal neutral environment demonstrated a trend towards higher milk fat in dairy cows fed fresh total mixed ration (TMR) at 9 pm compared to cows fed at 9 am. To confirm this result, a 6 wk feeding trial with two groups of 14 lactating Holstein cows was conducted using a randomized complete block design. Cows received fresh TMR (97% DM, 18% DM CP, 36% DM NDF) at 9 am or 9 pm for ad libitum feeding allowing between 5 and 10% orts. Subcutaneous fat (back & hip) measurements were made using ultrasound at the beginning and end of the trial. Dry matter intake (24.36 kg/d), milk yield (42.9 kg/d), milk fat percentage (2.2%), milk protein percentage (3.3%), BW (645 kg), BCS (2.9) averaged across weeks and treatments were not affected by time of feed delivery. By the end of the trial, subcutaneous fat level of PM fed cows (1.53±0.35 mm) was 2 times that of AM fed cows (0.77±0.35 mm) but the treatment effect was significant only at $P = 0.18$. A significant effect might be found with a larger number of cows and a longer treatment duration since subcutaneous fat variation was large. The above results suggest a possible improved efficiency of energy utilization with PM feeding since the PM fed cows tended to lay down more subcutaneous fat while producing the same amount of milk fat as the AM fed cows. Milk fat percentage decreased from 2.5% to 1.7% from wk 1 to wk 6, even though the composition of the TMR was constant. The milk fat results suggest that the cows were sorting the TMR which had a high dry matter content. Also, the absence of a milk fat response to PM feeding might relate to the milk fat depression that occurred during the study.

Key Words: Time of feeding, Milk production, Subcutaneous fat

414 Impact of providing total mixed ration at evening vs. morning on feed intake, rumen pH, and productivity of lactating Holsteins. A. Nikkhah*, J. C. Plaizier, C. Furedi, and A. D. Kennedy, *University of Manitoba*, *Winnipeg, MB, Canada*.

The impacts of providing fresh total mixed ration (TMR) either at 0900 or at 2100 h on lactation performance were studied using four multiparous (645 ± 75 kg BW; 90 ± 33 days in milk) and four primiparous (576 ± 46 kg BW; 77 ± 25) Holstein cows. A cross-over design with two 6-week periods was used. The first 3-week of each period were for adaptation and the last 3-week for data collection. The TMR contained a 50% concentrate on a dry mater basis. Rumen fluid

was sampled at 0000 and 1200 h at day-5 of week-5 via rumen cannula from four cannulated cows (3 primi- and 1 multiparous) and using oral probe from four non-cannulated cows. Cows were milked twice daily at 0430 and 1630 h. Nutrient digestibility was measured using total fecal collection technique during week-4. Results were analyzed with SAS (v. 9.1) as a linear mixed model including the fixed effects of time of feeding, parity, and time of feeding × parity; and the random effects of cow within parity and period. Provision of fresh TMR at 2100 h instead of 0900 h enhanced dry matter intake in primiparous cows (20.7 vs. 18.5 ± 0.96 kg/d, $P < 0.05$) but not in multiparous cows (20.6 vs. 21.0 kg/d), and improved the apparent total tract digestibility of dry mater (63.4 vs. 60.6 ± 0.63%, $P < 0.01$), NDF (50 vs. 45 ± 0.6%, $P < 0.001$), and ADF (45 vs. 41 ± 1.3%, $P < 0.05$) in all cows. Time of feed delivery did not affect milk yield, milk protein yield, and rumen pH. Milk fat yield tended to increase (1.1 vs. 0.96 ± 0.05 kg/d, $P = 0.07$) when cows were fed at 2100 h instead of 0900 h. Rumen pH was lower at 3 h postfeeding than at 15 h postfeeding (6.21 vs. 6.40, $P = 0.01$). No interactions were found between the time of feed delivery and time of rumen sampling on rumen pH. Results suggest that evening rather than morning provision of fresh TMR can improve feed intake, milk fat, and nutrient digestibility. Parity appears to affect the impact of time of feeding on cow performance, notably feed intake and milk protein.

Key Words: Time of feeding, Productivity, Lactating Holsteins

415 Beef cattle diets and forage optimization strategies on western rangelands. T. DelCurto*, *Oregon State University*, *Union*.

Ruminant Nutrition: Identifying Opportunities for Maximizing Forage Utilization?

Beef cattle distribution and use patterns are a continual challenge for livestock and land managers in the western US. Designing grazing management plans that optimize animal performance while maintaining or improving native vegetation are critical goals of land managers. To achieve these goals, the manager needs to understand how biotic (cow age, breed, stage of production, experience, etc) and abiotic (slope, aspect, vegetation type, soil depth, etc.) factors influence grazing distribution and diet selection. Pasture distribution and diet selection of beef cattle are influenced by the animal's nutritional requirements and the availability, palatability, and nutritional quality of the vegetation. The availability of water and the diurnal pattern of grazing relative to water location clearly illustrate the importance of water and associated vegetation in beef cattle thermal regulation and grazing distribution. However, the role of vegetation quality (CP, NDF, ADF, IVDMD, and DM), in predicting beef cattle distribution and use patterns, is less clear. In comparison to other herbivores, cattle have strong preferences for herbaceous vegetation even when woody vegetation is superior in nutrient density. Changes in vegetation are a function of landscape characteristics and, as a result, are often confounded with attributes such as elevation, topography, aspect, slope, and surface water. Past research has documented grazing behavior differences due to breed, age, and lactation status, suggesting that beef cattle nutrient requirements also influence grazing distribution and use patterns.

Key Words: Beef cattle, Rangelands, Diet quality

416 Nutritional management strategies for effcient utilization of forage resources. F. T. McCollum*, *Texas A&M University*, *College Station*.

The descriptors efficient and sustainable are used in the narrative describing this symposium. Efficiency and sustainability can be discussed in both biological and economical terms. Because of the inter- and intra-year fluctuations in climate, the quantity and quality of forage and the environmental stressors on grazing cattle are never identical from one year to the next. Hence it is a complex and difficult task to optimize efficiency. Perhaps a more important objective is to manage production risk so that actual production outcomes may approximate projections and over time the business enterprise is economically sustainable. Nutritional management is a key part of a production risk management program in beef cattle systems that rely upon grazed forage. Supplemental feeding is the most common means of managing risk associated with variations in forage quality and availability. Strategic supplementation decisions should address quantity and quality of available forage, timing of supplementation within the year to achieve the greatest response, method of delivery, and herd management to reduce supplement inputs. In addition, efficient use of the forage resource may also address landscape utilization issues. Placement and delivery of supplements can be used to influence grazing patterns and therefore efficient landscape use. With increased land values, labor, equipment and fuel costs, cattle producers must begin to address nutritional management with more year-to-year flexibility in order to attempt to optimize their programs.ced on a landscape.

Key Words: Nutrition, Beef, Forage

417 Nutritional wisdom revisited: From instinct to experience with implications for use of forages by herbivores. F. D. Provenza*, *Utah State University*, *Logan*.

During the past century, the notion of nutritional wisdom – referred to as "genetic programming" of ingestive behavior and as the "subconscious but irresistible desire" to restore biochemical equilibrium – was discounted when researchers found lactating dairy cows did not instinctively ingest recommended levels of calcium and phosphorus when offered dicalcium phosphate, sheep did not rectify a phosphorus deficit by consuming supplemental dicalcium phosphate, and dairy cows offered choices did not consistently select appropriate minerals and vitamins, though the cows fed different diets did not perform differently during 16-week trials. Finally, when lambs did not eat sufficient amounts of minerals, and because they tended to over-consume some minerals, researchers recommended feeding a complete ration, or if that is not possible, to offer free choice a complete mineral mix. Collectively, these studies fostered the notion that domestication had erased "nutritional wisdom" and the "innate ability" to select needed nutrients, a trait that through evolution still confers survival value to wild herbivores. These conclusions should be reconsidered in light of current understanding of how nutritional wisdom is likely to be manifest. It is unlikely several million years of evolution have been erased by a few thousand years of domestication. Acquiring nutrients and avoiding toxins is as important as breathing, which has not changed due to domestication. Indeed, mechanisms for detecting and correcting