there was a significant N x S interaction (P < 0.036) following the same pattern above for 4-methylphenol, and a tendency for this interaction to affect phenylacetic acid (P < 0.092). During the third collection period, phenol concentration was significantly altered by N (P < 0.013) and a N x S interaction (P < 0.029), with phenol increasing with reduced S content in the presence of elevated N, and decreasing with reduced S content in lower N diets. 3-methylindole tended to be affected by N (P < 0.079), while propanoic acid tended to be affected by S (P < 0.092). Reduction of N and S in swine finishing diets does not affect growth performance but can alter the concentration of components implicated in the odorous qualities of swine waste.

**Key Words:** Waste, Odor, Swine


A trial was conducted to examine the effects of dietary supplementation of natural binding compounds, i.e., diatomaceous earth and zeolite, on fecal excretion of major odor-causing compounds in growing-finishing pigs. Six Yorkshire barrows, with an initial BW of 19 kg, were fed six diets according to a 6 x 6 Latin square design. The diets were corn and soybean meal-based, contained the same amount of CP and AA and differed in the source and level of binding compounds. Diet 1 had no binding compounds and served as the control; diets 2, 3 and 4 contained 1.2, 2.4 and 3.6% of diatomaceous earth; diets 5 and 6 contained 0.6 and 1.2% of zeolite. Ammonia and volatile sulfide contents were analyzed by spectrophotometric analysis, and other odor-causing compounds were determined by using a gas chromatography-mass spectrometer. Supplementing diatomaceous earth and zeolite did not affect the fecal excretion of ammonia, short-chain fatty acids, p-cresol or indole. However, adding diatomaceous earth at the levels of 2.4 and 3.6% (diets 3 and 4) decreased (P = 0.07 and 0.05) the fecal excretion of total volatile sulfides (2.98 and 2.87 vs. 4.52 g H₂S·kg⁻¹ DM) in comparison with the control diet. In conclusion, adding suitable levels of diatomaceous earth and zeolite in swine diets may effectively decrease volatile sulfide-associated odor and pollution to the environment.

**Key Words:** Diatomaceous earth and zeolite, Odor-causing compounds, Pigs

5. **1590** Efficacy of various microbial urease inhibitors in controlling ammonia and volatile sulfide emission from swine manure slurry. T. C. Rideout* and M. Z. Fan, University of Guelph, Guelph, Ontario.

Three experiments were conducted to evaluate the effectiveness of the microbial urease inhibitors phenylphosphorodiamidate, N-(n-butyl)thiophosphoric triamide, and acetohydroxamic acid in reducing ammonia (NH₃) and volatile sulfide (in hydrogen sulfide unit, H₂S) emission from stored swine manure slurry. Liquid manure slurry was collected from the University of Guelph Arkell Swine Research Station and treated with six graded dosages (0.00, 0.40, 0.80, 1.20, 1.60, and 2.00 g/kg DM manure slurry) of the aforementioned urease inhibitors according to a completely randomized block design. Cumulative NH₃ and H₂S emission was measured over a 7-d period in an in vitro measurement system. Ammonia-nitrogen, urea-nitrogen, and volatile sulfide contents of the manure slurry were analyzed at the start and the end of the 7-d emission measurement. There were no differences (P > 0.05) in NH₃-N, urea-N, and H₂S contents in the manure slurry at the end of the 7-d emission measurements among the six dosages of the urease inhibitors. As urea hydrolysis in the manure slurry was complete at the start of the emission measurement, there were no differences (P > 0.05) in NH₃ emission rates in response to the addition of the urease inhibitors. However, the control groups appeared to have a lower rate of H₂S emission in comparison with the urease inhibitor-treated groups. While the results of this study suggest that the effectiveness of microbial urease inhibitors in controlling NH₃ emission from animal waste is strongly dependent on the time of application, more work is needed to clarify the dose-response relationship between urease inhibitors and volatile sulfide emission from swine manure slurry.

**Key Words:** Microbial urease inhibitors, Swine manure slurry, Ammonia and sulfide emission

### Ruminant Nutrition
### Rumen Fermentation


Six Holstein cows were used in a 3 x 3 replicated Latin square design to investigate the effect of different particle sizes of ground barley grain on lactation performance. Geometric mean diameters of the barley particles were 0.94, 1.93 and 2.99 mm for treatment 1, 2 and 3 respectively. Diets were only different in barley particle size and all cows received diets containing 40 percent corn silage and 60 percent concentrate (DM basis). About 50 percent of the concentrate was ground barley with different particle sizes. The differences among dry matter intake (DMI), milk fat percentage, milk total solid percentage, daily fat yield, dry matter digestibility, urine, and ruminal pH, daily body weight change, and fecal particle size distribution were not significant. Treatment 3 caused a decrease (P < 0.05) in milk protein percentage, daily milk yield, and fecal pH compared to treatment 1 and 2, but the differences between treatment 1 and 2 were not significant. With increasing barley particle size, fecal dry matter was increased and daily milk protein yield was decreased significantly (P < 0.05). Differences between treatments 1 and 2 or 2 and 3 for 4 percent FCM, 4 percent FCMDM/DMI daily; milk lactose yield, daily total solids yield and organic matter digestibility were not significant, but differences between treatments 1 and 3 for 4 percent FCM and 4 percent FCMDM/DMI were observed. The soluble fraction, the potential degradable fraction, the ruminal degradation rate and the effective degradability of dry matter increased linearly for treatments 1, 2 and 3 respectively. It is concluded that fine grinding of barley which is commonly used on dairy farms improved OM digestibility, milk yield, protein percentage and production and would be recommended for nutrition conditions similar to the present experiment.

**Key Words:** Barley, particle size, Dairy cow

7. **1592** Determination of energy values and degradability characteristics of triticale varieties. Ulku Gursoy* and Aydan Yilmaz, Ankara University Agriculture Faculty, Ankara, Turkey.

The objective of this research was to investigate the rumen degradability characteristics and energy values of triticale varieties used in ruminant nutrition in Turkey. Three Anatolia Merinos rams (3 yr old and 70 kg live weight) fitted with ruminal cannulas were used. Animals were fed the same ration during the trial. To determine rumen degradability characteristics, triticale varieties were incubated in nylon bags for 2, 4, 8, 16, 24, and 48 h in the rumen. Degradability characteristics of DM (dry matter) and OM (organic matter) of feed samples were determined using the equations $P = a + b(1-e^{-cP})$ and $Pe = a + b(c + e)^k$ (McDonald 1981). Effective ruminal degradabilities (at an assumed passage rate of 0.05/h) of triticale varieties for DM and OM were: Presto, Karma 2000, Tatlycak 97, and Tacettinbey 76.37, 77.77; 67.97, 70.90; 76.87, 79.57; and 74.94, 77.47. Degradability (%) in 48 h were: 91.35, 91.35; 82.66, 84.19; 88.40, 89.82; and 87.36, 88.62 respectively. The enzyme technique (in vitro) was used to estimate energy values. The ME values (kcal/kg DM) of triticale varieties were 3079, 3012, 3065, and 3046, respectively. Differences for DM and OM (based on DM) effective degradabilities for Presto, Tatlycak, and Tacettinbey varieties were not significant (P > 0.05), but the Karma 2000 variety was lower (P < 0.05). When the same varieties were compared for ME values, the Presto and Tatlycak varieties did not differ (P > 0.05), but differences between the other varieties were significant (P < 0.05). *This research was summarized from the M.S. thesis of Ulku Gursoy, Ankara University Agriculture Faculty, Department of Feeds and Animal Nutrition.

**Key Words:** Varieties of Triticale, Nylon Bag Technique, Method of Cel lulase, Degradability
The present study aimed to investigate the metabolism of 1,2-propanediol (PPD; propylene glycol) by studying glucose kinetics and plasma metabolite concentrations in lactating cows without interference from the mammary gland microbiota. Three rumen-cannulated cows (14, 20, and 25 kg milk/d) were subjected to three washed reticulo-rumen infusion treatments in a Latin square design. The treatments were control (acetic + butyrate), propionate (control + propionate), and PPD (control + PPD). The absorption rate of each of the metabolites was maintained for 420 min by continuous intra-ruminal infusion of the nutrients into 30 L of bicarbonate buffer placed in the reticulo-rumen. The irreversible loss rate of glucose as well as the relative enrichment of lactate into 30 L of bicarbonate buffer placed in the reticulo-rumen. The irreversible loss rate of glucose even in ruminants deprived of the ruminal propionate absorption.

Key Words: Ruminant, Propylene glycol, Metabolism


This study compares rumen evacuation and gas production as means to screen forages. Eight cultivars of perennial ryegrass (Lolium perenne) were cut daily at the same age (4 weeks re-growth) and stall-fed to six rumen-cannulated, high-producing, Holstein-Friesian dairy cows in 7 periods of 1 week each. Cultivars 1 to 3 were each fed to 3 cows in periods 1, 3, 5, and 7, whereas cultivars 1 to 6 were each fed to one cow in periods 2, 4, and 6 in a 3 x 3 Latin square design. At the end of the second week, cows were rumen-evacuated twice, and the fractional NDF degradation rate (kd) was estimated using ADL as an internal marker for solid particles passage. Grass samples were also taken, freeze-dried, ground, and fermented for 72 hours using the automated gas production technique. The resulting gas production curves were fitted using dual-pool Logistic and Gompertz models. In these models the second pool is assumed to represent the non-soluble (fiber) fraction, and allows the estimation of the specific fermentation rate of the fiber. The kd based on evacuation was lower than that based on gas production (2.57 VS 5.40%/h). Moreover, ranking of cultivars was different between techniques. Rumen evacuation showed that cultivars 7 and 8 had faster kd than the other cultivars, whereas, data from gas production showed the opposite as cultivars 7 and 8 had the slowest kd. Rumen evacuation refers to the declining total NDF pool in the rumen and it estimates kd of the total NDF fraction. Whereas, gas production refers to the growing gas pool and it estimates kd of the potentially degradable NDF fraction with the assumption that the rate of gas production is directly proportional to substrate degradation. Moreover, with gas production the second pool is often assumed to represent the fiber fraction, though it actually represents the slowly fermentable fraction, which may or may not be fiber. Therefore, it can be concluded that these techniques are not comparable for these forages.

Key Words: Rumen-evacuation, Gas-production, Degradation rate

Effect of stage of growth on the protein and carbohydrate subfractions of alfalfa and Timothy hay. P. Yu1, D. A. Christensen1, and J. J. McKinnon1, 1Department of Animal and Poultry Science, University of Saskatchewan.

The two varieties of alfalfa (Medicago sativa L. cv. Pioneer, Beaver) and timothy (Phleum pratense L. cv. Climax, Joliette) hay grown at three different locations (N=3) were cut at three stages of growth: 1=early bud for alfalfa and joint for timothy; 2=late bud for alfalfa and pre-bloom for timothy; and 3=early bloom for alfalfa and full bloom for timothy. The objective was to investigate the effect of variety and maturity stage on the degradable crude protein (CP) (PA, PB1, PB2, PB3, PC) and carbohydrate (CHO) (CA, CB1, CB2, CC) subfractions as partitioned by the Cornell Net Carbohydrate Protein System. The results showed that comparing alfalfa and timothy means, alfalfa contained higher (P<0.05) levels of PA (41.5 vs. 16.5 % CP), PB3 (27.2 vs. 21.3 % CP), PC (8.6 vs. 5.2 % CP; P=0.08), CA (36.0 vs. 14.7 % CHO) and CC (35.1 vs. 16.4 % CHO), but lower (P<0.05) levels of PB1 (8.4 vs. 23.6 % CP), PB2 (10.7 vs. 33.5 % CP) and CB2 (27.4 vs. 67.6 %CHO). Forage variety had little effect, however, stage of growth influenced both the CP and CHO subfractions. As plant maturity advanced from stage 1 to 3, the rapidly degradable CP fraction (PA) was reduced (P<0.05) in alfalfa (51.2 vs 34.8% CP), but increased (P<0.05) in timothy (9.2 to 27.5% CP); the rapidly degradable CP fraction (PB1) increased (P<0.05) in alfalfa (0.0 to 25.2% CP) but decreased (P<0.05) in timothy (31.6 to 16.7% CP); the intermediate degradable CP fraction (PB2) was reduced (P<0.05) in both forages (alfalfa: 14.1 to 5.2% CP; timothy: 37.8 to 29.4% CP); the slow degradable CP fraction (PB3) was reduced (P<0.05) in alfalfa (33.1 to 17.7% CP) but not in timothy (averaging 21.3% CP); the unavailable CP fraction (PC) was increased (P<0.05) in alfalfa (3.5 vs 17.1% CP) but not in timothy (averaging 5.2% CP). As plant maturity advanced, CHO subfractions in both forages were impacted to a lesser degree than the CP subfractions. The results indicate that within each forage species, stage of growth has a greater impact than variety on the partitioning of CP and CHO, into fractions that vary in availability to fermentation by rumen microbes.

Key Words: Protein and Carbohydrate Subfractions, Forage Quality, Maturity and Variety


Soyhulls (SH), a by-product of soybean processing, can be used as a replacement for corn grain in dairy cattle diets because of their high content of fermentable fiber. Five multiparous Holstein cows cannulated in the rumen and duodenum that averaged 63 DIM were used in a 5x5 Latin square design to evaluate the substitution of SH for corn in diets. Contents 23% alfalfa silage, 23% corn silage, and 54% concentrate on DM basis. Reported SH replaced corn to supply 0, 10, 20, 30, or 40% of the dietary DM. Intakes of DM and OM and OM truly digested in the rumen were unaffected by treatments (P>0.05; mean = 21.6, 20.0, 8.1 kg/d, respectively). The intake of NDF (5.9, 6.3, 7.7, 8.9, and 9.4 kg/d) increased linearly (P<0.01), but the intake of NSC (8.5, 6.7, 6.0, 5.0, and 3.7 kg/d) decreased linearly (P<0.01) as SH increased from 0 to 40% of the dietary DM. As SH replaced corn in the diet, the amount of NDF digested was increased whereas the amount of NSC digested was decreased in the rumen (NDF = 2.6, 2.6, 3.6, 3.6, and 4.2 kg/d; P<0.01; NSC = 1.8, 2.1, 1.0, 0.6, and 0.3 kg/d; P<0.01), in the lower digestive tract (NDF = 0.6, 0.9, 0.9, 1.6, and 1.4 kg/d; P<0.04; NSC = 6.0, 4.2, 4.6, 4.1, and 3.0 kg/d; P<0.01) and in the total tract (NDF = 3.2, 3.5, 4.5, 5.2, and 5.5 kg/d; P<0.01; NSC = 7.8, 6.3, 5.6, 4.6, and 3.3 kg/d; P<0.01). Passage to the duodenum of nonammonia N, microbial N, nonammonia nonmicrobial N, total essential AA, total nonessential AA, and total AA were not affected by treatments (P>0.05; mean = 574, 304, 270, 1389, 1665, and 3053 g/d, respectively). Differences in the source of energy (fiber vs. NSC), in the amounts of fiber and NSC digested, and in the site of digestion in the gastrointestinal tract may cause a shortage of energy that decreases milk production when more than 30% of the dietary DM that is supplied as corn is replaced with SH.

Key Words: Soyhulls, Ruminal fermentation, Nutrient digestion
We hypothesized that the use of crotonate as an electron sink could relieve the constraints on fermentation caused by the CH₄ inhibitors lumazine, propynoate, and ethyl 2-butynoate. In three experiments with 24-h mixed rumen batch cultures, lumazine (0, 0.3 and 0.6 mM, Exp. 1), propynoate (0, 2 and 4 mM, Exp. 2), and ethyl 2-butynoate (0, 4 and 8 mM, Exp. 3), were each incubated in 160 mL Wheaton bottles (n = 4) with crotonate (0 and 8 mM with lumazine, 0 and 4 mM with propynoate, and 0 and 4 mM with ethyl 2-butynoate). Ground alfalfa hay was the substrate. Lumazine, propynoate, and ethyl 2-butynoate decreased (P < 0.01) CH₄ production by 9, 70, and 94%, respectively. Crotonate tended (P = 0.11) to increase A/P in Exp. 3. Lumazine increased (P = 0.02) A/P, while both propynoate and ethyl 2-butynoate decreased (P < 0.01) it. The inhibition of methanogenesis by propynoate and ethyl 2-butynoate caused (P < 0.01) the accumulation of H₂, formate, and ethanol. In all the experiments, crotonate increased (P < 0.01) butyrate molar percentage. Crotonate did not overcome the decrease in fermentation caused by the CH₄ inhibitors.

**Key Words:** Rumen, Methane, Inhibition

### 1598 Effects of natural plant extracts on nitrogen metabolism and fermentation profile in continuous culture. M. Busquet¹, S. Calsamiglia², A. Ferret³, and C. Kamel², ¹Universitat Autonoma de Barcelona, Spain, ²Aixis France.

Eight 1.3-L dual flow continuous culture fermenters were used in two periods (10 d) to study the effects of natural plant extracts on N metabolism and fermentation profile. Fermenters were fed 95 g/d of a 60 to 40 forage to concentrate diet. Treatments were: no extract or negative control (C), Monensin (1.75 mg/d per fermenter, M), or 7.5 mg/d per fermenter of Fennugreek (F), Cade (GA), Tea Tree (T), Dillweed (D), Ginger (G) or Clove Bud (CL). Fermenters were maintained at constant temperature (39 C), pH (6.4) and solid (5%) and liquid (10%) 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 2 days, samples were taken at 0, 2, 4, 6, and 8 h after the morning feeding, and analysed for peptide (Pep), aminoacid (AA) and NH₃ N concentrations. Data were analyzed using the PROC MIXED (SAS, 1996) and significance declared at P < 0.05. Total VFA was similar across treatments (111.1 mM). Acetate concentration (mol/100mol) was lower for CL (57.5) compared to C (61.9) and M (61.1). Propionate concentration (mol/100mol) was higher in CL (28.0) versus C (23.2) and M (24.2). The Pep-N concentration across all hours (mg/100ml) was higher for CL (6.93) compared to C (3.84) and M (4.18). The AA-N concentration across all hours (mg/100ml) was numerically lower in CL (2.85) and higher in C (5.27) and M (5.17). The NH₃-N concentration across all hours (mg/100ml) was numerically higher in M (9.55) and lower in CL (6.43). The accumulation of Pep-N, and the decrease in AA-N in C suggested that proteolysis was inhibited.

**Key Words:** Microbial fermentation, Plant extract

### 1599 Influence of grain density on rumen and digestive characteristics. A. Offner¹, A. Bach², and D. Sauvant², ¹INA P-G INRA, Paris, France, ²Agribigrams, Barcelona, Spain.

The effect of technological treatment of cereals on ruminant digestion has been poorly quantified. The objective of this study was to evaluate the use of increasing grain density (D) as a predictor of treatment effects.

A database on ruminal digestibility in cattle pooled 21 references and 69 treatments studying the influence of grain density. Corn and sorghum were used in 80% of the references. Treatments were mostly steam flaking and dry rolling and the corresponding grain density ranged from 170 to 684 g/L (D = 389 ± 100 g/L). Statistical analyses of the data used GLM models and integrated the experimental effect as a qualitative variable. The results showed the large effect of density on several key parameters. Decreasing density significantly increased ruminal starch digestibility (Starch DR = 73.7 ± 15.8%); Starch DR, % = 99.88 - 0.063D (n = 58, n exp = 20, R² = 93.2%, rsd = 5.1%). Consequently, ruminally fermented organic matter (RFOM) = 61.6 ± 12.0% DM increased by 21% when density dropped by 100 g/L. Organic matter digestibility in the total tract (dOM = 73.9 ± 8.0%) increased similarly: dOM, % = 84.04 - 0.025D (n = 46, n exp = 16, R² = 93.7%, rsd = 2.5%). The treatments had an effect on microbial protein formation (MCIP = 73.7 ± 16.5% DM), which increased when density decreased: MCIP, % DM = 83.82 - 0.021D (n = 33, n exp = 12, R² = 95.3%, rsd = 4.5% DM). Nevertheless, the in situ protein density on rumen pH (pH exp = 6.0 ± 0.3) was also noticeable: pH = 5.54 + 0.001D (n = 38, n exp = 13, R² = 94.4%, rsd = 0.1). Adjacent pH was under 6 for density below 460 g/L. Grain density is a simple quantitative parameter, which can be used to predict some ruminal parameters. It is concluded that the digestive effects of technological treatments such as steam flaking can largely be captured considering density effects.

**Key Words:** Rumen, Grain density, Steam flaking

### 1600 The binding and degradation of nisin by mixed ruminal bacteria. S.S. Lee¹, H.C. Mantovani¹, and J.B. Russell², ¹Cornell University, ²ARS/USDA.

Monensin and the bacteriocin, nisin, have similar effects on ruminal fermentation, and bacteriocins have been suggested as another means of altering ruminal fermentation. Because monensin and nisin both catalyze potassium efflux from sensitive bacteria, potassium depletion can be used as an index of sensitivity. Nisin catalyzed potassium efflux from glycolyzing S. bovis cell suspensions, and the steady state concentration of residual potassium was dependent on the amount of nisin added. The relationship between nisin concentration and potassium depletion was a saturation function that had considerable cooperativity. By pre-incubating mixed ruminal bacteria with nisin and removing them prior to S. bovis JB1 addition, it was possible to estimate the ability of mixed ruminal bacteria to bind or degrade nisin. Low concentrations of mixed ruminal bacteria did not bind or degrade all of the nisin in 6 h, but little nisin remained if the mixed ruminal bacteria were present at more than 50 g protein per ml. Because cell-free ruminal fluid (10% v/v) inactivated the nisin in less than 2 h, and this inactivation could be counteracted by autoclaving, ultra-filtration and protease inhibitors it appeared that there was an enzymatic degradation of nisin. Nisin degraded to degrade did not prevent potassium depletion from mixed ruminal bacteria. These latter results indicated that nisin binding was faster than nisin degradation. The idea that nisin binding could protect nisin from degradation was supported by the observation that intact nisin could be extracted from mixed ruminal bacteria. These observations support the hypothesis that bacteriocins can be used to modify ruminal fermentation, but further work will be needed to see if these peptides can be produced economically.

**Key Words:** Rumen, Bacteriocin, Fermentation

### 1601 A decision support system to evaluate methane and nitrogen emissions from dairy cows. E. Kebrab¹, J.A.N. Mills, L.A. Crompton, and J. France, The University of Reading, Reading, United Kingdom.

Methane and nitrogen (N) emissions from dairy cattle are major contributors to environmental pollution arising from agriculture. The agricultural industry needs to reduce its emissions considerably, and research has demonstrated that one way to achieve this goal is through dietary manipulation. To this end, a few technical models have been developed to evaluate environmental pollution. However, few if any, combine the effects of more than one pollutant and most are too technical and detailed to be used efficiently by farmers or farm advisors. The objective of this study was, therefore, to integrate published, dynamic models describing methane and N metabolism in the lactating dairy cow, and...
was the primary source of starch. Infusion treatments were mixtures of sodium propionate and sodium acetate, at ratios of 0.5, 1.4, 2.3, 3.2, 4.1 and 5.0, infused into the rumen continuously for 18 h starting 6 h before feeding at a rate of 21.7 mmol of sodium VFA/min. We hypothesized that propionate infusion decreases DMI by stimulating oxidative metabolism in the liver. We expected greater hypoxic effects of propionate for EL compared to ML because of greater oxidative metabolism of non-esterified fatty acids in the liver for EL compared to ML (plasma concentration: 275 and 76 meq/L, EL and ML, respectively; P < 0.001). Propionate infusion decreased DMI for EL and ML, but a quadratic effect of propionate infusion was observed for ML only (interaction P < 0.10), indicating a greater reduction in DMI at higher doses of propionate for ML compared to EL. Contrary to our hypothesis, propionate infusion linearly increased interval meal for ML but not EL, but decreased meal size similarly for both stages of lactation. Greater milk yield for EL compared to ML (42.0 vs. 30.8 kg/d P < 0.001) probably increased glucose demand of peripheral tissues and decreased the relative proportion of infused propionate oxidized in the liver, delaying the sense of hunger. Glucose demand of peripheral tissues might alter hypoxic effects of propionate by affecting the extent of oxidative metabolism in the liver.

Key Words: Propionate, Oxidative metabolism, Glucose demand

1604 Monensin by fat interactions on trans fatty acid concentrations in cultures of mixed ruminal microbes grown in continuous fermenters fed corn or barley. T. C. Jenkins*1 and V. Fellner2, 1Clemson University, Clemson, SC, 2North Carolina State University, Raleigh, NC.

In previous studies, monensin (M) and unsaturated plant oils independently increased trans fatty acid concentrations in cultures of mixed ruminal microbes. This study was conducted to determine if combining M with plant oil yielded interactions on trans fatty acid concentrations in cultures of mixed ruminal microbes or their effects were additive. Four continuous fermenters were fed 14 g of dry feed per day (divided equally between two feedings) consisting of alfalfa hay pellets (30% of DM) and either a high corn (HC) or a high barley (HB) concentrate (70% of DM) in each of two fermenters. Within each grain type, one fermenter was supplemented with M (25 ppm) and the other fermenter was supplemented with 5% soybean oil (SBO) during 5 to 8. Monensin and SBO were added together in all fermenters during 9 to 12. Samples were taken at 2 h after the morning feeding on the last day of each period and analyzed for fatty acids by gas chromatography. A second run of the fermenters followed the same treatment sequence to give additional replication. Average pH across all treatments was 6.15, which was reduced (P < 0.01) by M but not affected by SBO. Monensin reduced (P < 0.05) the ratio of acetate to propionate, which averaged 2.03 across all treatments; fat decreased the acetate to propionate ratio in cultures not receiving M but increased it in the presence of M. Monensin and SBO altered the concentration of several trans fatty acids, but the only interaction was a grain x M x SBO interaction for trans-10 C18:1. The increase in trans-10 C18:1 by the M and SBO combination exceeded the sum of increases in trans-10 C18:1 for each individual feed additive, but only for HB. For the HC diet, M increased (P < 0.05) trans-10 C18:1 more than fat alone and more than the M and SBO combination. The results of this study show that M and SBO effects are additive for all trans fatty acids except for trans-10 C18:1. In the case of trans-10 C18:1, M and SBO interaction gave higher trans-10 C18:1 concentrations in ruminal contents than would be expected simply by adding their individual effects, but only for HB. Because some trans fatty acid isomers has been associated with milk fat depression in dairy cows, these results suggest more severe depressions in milk fat content when cows are fed M along with unsaturated plant oils.

Key Words: Monensin, Trans Fatty Acids, Continuous Cultures

1605 Utilization of fermentable carbohydrate and protein by ruminal microbes in continuous cultures. K.S. Mohney1, V. Fellner1, A.L. Mueller2, R.L. Belyea2, and M.L. Gumpertz3, 1North Carolina State University, Raleigh, NC, 2University of Missouri, Columbia, MO.

A major factor in maximizing microbial protein synthesis is the availability of rumen protein. One objective of this study was to determine the effect of fermentable carbohydrate and protein on microbial fermentation. Mixtures were formulated using three ingredients, soybean meal and available rumen protein.
(SBM), ground corn (GC) and soybean hulls (SBH). Corn and SBH were used in ratios of 60:20, 40:40 or 20:60, respectively, to prepare high (HC), medium (MC) or low (LC) corn diets. Soybean meal was included either unextruded (control) or extruded at L (L), medium (M) or high (H) temperature. Degradability of the N fractions in the control, L, M and H soybean meal were, 97, 80, 80 and 60%, respectively. Diets were arranged as a 3 x 4 factorial (3 levels of corn/soybean hulls and 4 levels of protein) and analyzed according to a split plot design. Total volatile fatty acids were not affected (P >0.10) by dietary treatments and averaged 70.9 mM across all diets. Diets had no effect on molar ratios of acetate, propionate and butyrate which averaged 60.2, 25.0 and 11.9. Compared to the unextruded SBM, extrusion increased (P <0.10) molar proportion of isovalerate but only in the HC diets. Varying the level of fermentable carbohydrate had no affect on ruminal pH. Extrusion altered pH in the HC and MC diets. In the HC diets both the L and M extrusion temperatures lowered (P <0.05) pH (5.5 and 5.5, respectively) compared to H or the control (5.9 and 5.8, respectively). In the MC diets, the extrusion temperature resulted in the lowest (P <0.05) pH. Extrusion temperature altered ammonia concentrations. In the LC diets, both L and H increased (P <0.10) ammonia concentration (32.1 and 32.2 mg/dl, respectively) when compared with M and the control (25.6 and 21.0 mg/dl, respectively). Methane concentration averaged 581 nmol/m and was not affected by dietary treatment. The HC and MC diets increased (P <0.05) bacterial nitrogen percentage (9.4 and 9.5%, respectively) compared to the LC diet (8.3%). Data suggest that the fermentability of the structural carbohydrates in SBH was similar to the high starch corn diets. Furthermore, large differences in protein degradability did not seem to have a major impact on microbial fermentation.

Key Words: Fermentable carbohydrate, Extrusion, Fermenters

**1606 Ruminant N intestinal digestibility estimated by mobile bag or “in vitro” technique.** M. de J. Marichal*, M. Carrquiry, and A.I. Trujillo, Facultad de Agronomía, Universidad de la Republica, Montevideo, Uruguay.

Same batch wet and dried brewers grain (WBG, DBG), sorghum distillers grains (SDG) and alfalfa hay (AAH) nitrogen intestinal digestibilities estimated by mobile bag technique (MB) or pepsin+p-pancreatin digestion (P+P) were compared. Fourteen polyester bags (6 x 7 cm containing samples of each feed were incubated (16 h) in rumen of three dry Holstein cows, two with duodenum cannulas, individually culled and fed (8am and 5 pm) 10 kg DM alfalfa hay. After incubation, bags were placed (2.5 h) in acid peptic-HCl solution (pH 2; 3 g peptic/L 0.1N HCl) in shaking water bath (38.5°C). Bags were then randomly assigned to intestine digestion or “in vitro” pancreatic incubation, 10 and 4 bags/feeds, respectively. Ten bags / cow (2 feedstuffs/day) were introduced (evening meal) into small intestine and recovered from from 8am to 5pm following day feces. For pancreatic digestion, bags were incubated (24h; 0.5M KH2PO4 pH 7.8 solution, containing 50 ppm thymol and 3g/L pancreatic) in shaking water bath (38.5°C). Feces recovered or pancreatic digested bags were machine washed (60 bags/washing batch, 45 min). Rumen ungraded N was estimated from six bags/feeds/stock incubated for 16h. Intestinal N digestibility was residual N in bags after intestinal or pancreatic incubation / ungraded N. Differences in N digestibilities resulted from: a) amounts DM after total digestion and proportion final DM / initial DM, which were higher in P+P than MB, and b) N concentration in final DM, although not patern was observed. Results suggest pancreatic digestion cannot replace small intestine incubation.

<table>
<thead>
<tr>
<th>Cow diet</th>
<th>Pasture</th>
<th>SE</th>
<th>Diet</th>
<th>SE</th>
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<td>k</td>
<td>SE</td>
<td>k</td>
<td>SE</td>
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<tr>
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N ≤ 0.0001

**Key Words:** Rumen, PCR technology, Bacteria

**1607 Development of a real-time quantitative PCR assay to control the yield of DNA extracted from rumen content samples spiked with an exogenous bacteria.** G. Talbot* and J. Chiquette 1 Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada, Lennoxville, QC.

Recent quantitative PCR-based technologies are now currently used to study rumen microbial ecosystems. They permit to quantify specific rumen bacterial species. We have developed a real-time quantitative PCR assay (TagMan technology from Applied Biosystems) to normalize for differences in efficiency of DNA extraction and purification from rumen content samples. For this purpose, known amounts of a bacterium not found in the rumen, *Thermus aquaticus*, were added into rumen content samples before DNA extraction. A primer pair and an internal probe were designed based on small subunit ribosomal DNA sequences that were specific to the *Thermus* strain used. No signal was obtained when using unspiked rumen content samples, suggesting that the designed set of oligonucleotides could not anneal to any other DNA found in the rumen. Results revealed a typical logarithmic amplification of DNA (correlation factor (R2) of 0.994) from TagMan PCR assays when using rumen content samples that were spiked with 2 x 105 to 2 x 108 *Thermus aquaticus* cells as DNA templates. A number as low as 14 cells of *Thermus aquaticus* could be amplified for 40 cycles. In addition to the normalization of the efficiency of DNA extraction and purification, the development of this assay will serve as a tool to correct for the presence of any possible substances interfering with the PCR process such as humic acids. A more precise picture of the rumen ecosystem and dynamics could be obtained when the exogenous bacteria, *Thermus aquaticus*, is used to spike rumen content samples.

**Key Words:** In *sacco*, forage


Evaluation and refinement of ruminal volatile fatty acid absorption equations in a dynamic, metabolic model of the lactating dairy cow. M. D. Hanigan*, D. C. Weisberg, F. Standaert, and L. R. Reuzel, Purina Mills, LLC, St. Louis, MO.

Kohm et al. (1994) previously observed that ruminal volatile fatty acid (VFA) concentrations were not well predicted by the model of Baldwin et al. (1995). The objective of this work was to further evaluate the model and to understand the relative error due to different superscripts differ (P < 0.05).

Key Words: model, rumen, volatile fatty acids

Nucleic acid content and profile of protozoal and bacterial fractions isolated from ruminal contents of lactating dairy cows. L. T. Mydland* and H. Volden, Agricultural University of Norway.

The main objective of this study was to compare the kinetic of dry matter ruminal degradation of alfalfa hay and ciliotary hay (Clitorea ternatea) in sheep. R. Barajas*, M. Placencia1, A. Estrada1, and J.F. Obregon1, 1FMVZ-Universidad Autónoma de Sinaloa (Mexico).

With the objective of compare the kinetic of dry matter ruminal degradation of alfalfa hay and ciliotary hay (Clitorea ternatea) in sheep, an experiment was conducted. Four Pelibuey sheep (Females; BW = 32 kg), fitted with ruminal cannula (ID = 5 cm) were used in a complete randomized design experiment. Animals were placed individually in metabolic crates (0.6 x 1.2 m), fed (3% of BW) a 14% CP ration, containing 25% alfalfa hay (AH), 25% ciliotary hay (CH) and 50% concentrate. Fifty six Dacron bags (10 x 18 cm) were filled with 5.5 g of alfalfa hay, another fifty six bags were filled with ciliotary hay (5.5 g), randomized were grouped in 28 set of four bags (AH 2 bags and CH 2 bags); set of bags were assigned one of six incubation times (3, 6, 12, 24, 48, and 72 hours) in rumen of sheep. Solubility was measured placing bags in warm distilled water (39 C) five minutes. After incubation bags were washed, oven dried (110 C; 24 hours) and weighed, and dry matter disappearance was calculated and kinetics parameters and effective degradation were performed. DM solubility was similar (P > 0.10) for AH (27.6%) and CH (26.6%), respectively. Dry matter disappearance from bags were not affected (P > 0.05) by treatments in all rumen incubation times, except for 48 h incubation time, where AH was higher.

Key Words: RDP, Fiber quality, Continuous culture
The nutritive value of ground and expanded yellow corn in diets with tifton hay (Cynodon spp.) was determined using a randomized 4x2x5 factorial design (four levels x two processings x five replicates) in an apparent digestibility trial with sheep. The nutritive value of ground and expanded yellow corn in diets with tifton hay (Cynodon spp.) was determined using a randomized 4x2x5 factorial design (four levels x two processings x five replicates) in an apparent digestibility trial with sheep. The nutritive value of ground and expanded yellow corn in diets with tifton hay (Cynodon spp.) was determined using a randomized 4x2x5 factorial design (four levels x two processings x five replicates) in an apparent digestibility trial with sheep.
Rumen protozoal populations and fermentation characteristics were assessed in four cannulated Jersey heifers fed quillaja extract (QE, 60 g/d), quebracho tannin (QT, 6 g/kg diet), high linoleic acid safflower oil (SO, 200 g/d) or no dietary supplements (control, CON) in a 4 x 4 Latin square. The basal diet comprised (DM basis) 80% barley grain, 18% barley silage, 1% canola meal and 1% mineral, and was consumed ad libitum. All antiprotozoal agents (APA) tended (P = 0.1) to reduce total protozoal numbers, relative to CON, and all reduced (P < 0.05) Entodinium populations (log(10)/mL ruminal fluid), as compared with CON; in CON, QT, QE and SO, these were 6.2, 5.7, 5.9 and 5.8, respectively. Populations of Epidinium, Isotricha, Dasytricha, Diplodinium and Bifidobacterium spp. were lower (P < 0.001) with SO than with the other APA. With CON, QE, QT and SO diets, respectively, 2.0, 11.4, 5.7 and 0.2% of protozoa were cellulolytic. Treatment did not affect (P > 0.05) mean ruminal pH or concentrations of reducing sugars, ammonia, total free amino acids, soluble protein, peptides, total VFA or individual VFA except isobutyrate, for which CON and SO > QE > QT (P < 0.05). Isobutyrate was present at 1.28, 1.26, 1.19 and 1.08 mM with CON, SO, QE and QT, respectively. Feeding QE or SO reduced (P < 0.05) ruminal carboxymethylcellulase activity, compared to CON. Treatment did not affect (P > 0.05) nutrient intake or digestibility, duodenal nitrogen (N) flow or urea and glucose in blood. Urinary N excretion (as % of N intake) was lower (P < 0.05) with QT (57.7%) than with CON (66.3%), QE (65%) or SO (66.7%). All three compounds studied reduced Entodinium populations, which as a group have the largest negative impact on bacterial turnover in the rumen, with no adverse effects on fermentation or nutrient digestion. Thus, each may have potential for use as a selective agent for reducing the impact of Entodinium on bacterial N recycling in cattle.

Key Words: Rumen Protozoa, N Recycling, Cattle


Four-ruminally fistulated, multiparous, pregnant Holstein cows were utilized in a randomized design to delineate microbial adaptations as the cow transitioned from a non-lactational to lactational state. Microbial measurements were obtained 51 (far-off dry), 23, and 9 d (close-up dry) prepartum and 6, 20, 34, 48, 62, 76, and 90 d postpartum. Calculated NEL (Mcal/kg), measured crude protein (%) and digestibilities (based on steer fed the same diets at 2% of BW) of the diets were 1.46, 1.26, 1.19 and 1.08 mEq with CON, SO, QE and QT, respectively. Feeding QE or SO reduced (P < 0.05) ruminal carboxymethylcellulase activity, compared to CON. Treatment did not affect (P > 0.05) nutrient intake or digestibility, duodenal nitrogen (N) flow or urea and glucose in blood. Urinary N excretion (as % of N intake) was lower (P < 0.05) with QT (57.7%) than with CON (66.3%), QE (65%) or SO (66.7%). All three compounds studied reduced Entodinium populations, which as a group have the largest negative impact on bacterial turnover in the rumen, with no adverse effects on fermentation or nutrient digestion. Thus, each may have potential for use as a selective agent for reducing the impact of Entodinium on bacterial N recycling in cattle.

Key Words: Rumen Protozoa, N Recycling, Cattle

Effects of increasing levels of pelleted beet pulp substituted for high-moisture corn on rumen digestion kinetics and microbial protein efficiency in lactating dairy cows. J. A. Voelker* and M. S. Allen, Michigan State University.

Effects of increasing levels of pelleted beet pulp substituted for high-moisture corn were evaluated with 8 randomly and duodenally cannulated multiparous Holstein cows in a duplicated 4x4 Latin square design with 21-d periods. Cows were 79 ± 17 (mean ± SD) DIM at the beginning of the experiment. Experimental diets with 40% forage (corn silage and alfalfa silage) and 60% concentrate contained 0%, 6.1%, 12.1%, or 24.3% beet pulp (0BP, 6BP, 12BP, and 24BP, respectively) substituted for high-moisture corn on a DM basis. Diet contents of NDF and starch were 24.3% and 35.4% (0BP), 26.2% and 31.2% (6BP), 28.0% and 32.6% (12BP), and 31.6% and 18.6% (24BP), respectively. The rate of microbial protein digestion of starch decreased with increasing BP substitution (P < 0.01). This was caused by a linear increase in starch passage rate (P < 0.05), and a linear decrease in digestion rate (P < 0.01) of starch in the rumen, possibly the result of reduced amyloglucosidase enzyme activity of rumen fluid. Although substituting BP for corn decreased rumen starch digestibility, true rumen OM digestibility and microbial N flow to the duodenum were not affected by treatment (P > 0.20), nor was microbial nitrogen efficiency (MNE), expressed as microbial N flow to the duodenum as a percent of OM truly digested in the rumen (P > 0.20). MNE was not correlated to mean rumen pH (P > 0.40) or daily minimum pH (P > 0.60). MNE was positively correlated with passage rates of starch (r = 0.66, P < 0.001) and indigestible NDF (r = 0.64, P < 0.001), which were increased by substituting BP for corn (P < 0.05). Increasing passage rate probably increases MNE by increasing the rate at which microbes escape the stomach and predation in the rumen. Although substituting BP for high-moisture corn might have increased rate of microbial passage from the rumen relative to lysis, rumen microbial pool might have been reduced by lower starch fermentation, resulting in no overall effect on MNE.

Key Words: Beet pulp, High-moisture corn, Rumen microbial N efficiency
1625  Effects of NPN in alfalfa and red clover silages on production of lactating cows. J.J. Olmos Colmenares1, AF Brito1, GA Broderick, and SM Reynal, 1University of Wisconsin-Madison, 2US Dairy Forage Research Center.

Sixteen multiparous and 8 primiparous Holstein cows (8 ruminally fistulated) were randomly assigned to six 4 x 4 Latin squares to assess the effect of NPN level in alfalfa and red clover silages on milk production, ruminal metabolites, microbial protein synthesis, and ruminal escape of amino acids and peptides. The experimental diets contained (DM basis): 50% control alfalfa silage (AS), 50% formic acid-treated alfalfa silage (AAS), 50% red clover silage (RCS1, lower NDF and CP than AS), or 50% red clover silage (RCS2, similar to AS in NDF and CP). Diets were formulated to contain about 17% CP and NDF content was 28, 29, 27 and 29%, respectively, for diets AS, AAS, RCS1 and RCS2. DM and milk yield were higher for AS and AAS compared to RCS2, whereas RCS1 was intermediate. Fat and protein yield, MUN and rumen ammonia were higher for the alfalfa silages relative to both red clover silages. Apparent digestibilities of DM and NDF were highest on RCS2, intermediate on RCS1 and lowest on the alfalfa silages. Rumen pH, acetate, propionate and acetate:propionate ratio did not differ. RCS1 had higher N efficiency than the alfalfa silages while RCS2 was intermediate. Overall, feeding alfalfa silages resulted in greater DM and milk yield than feeding red clover silages; however, N utilization, BW gain, and nutrient digestibilities were greater in cows fed red clover silages.

### Sheep Species

#### 1626 Assessment of gestational age in Chall ewes by ultrasonography. Sarang Soroori1, Parviz Tajik2, and Abbas Veshkini, 1 Ferdowsi University of Mashhad, Faculty of Veterinary Medicine, Mashhad, Tehran, 2University of Tehran, Faculty of Veterinary Medicine, Tehran, Iran.

To assess gestational age by ultrasonography, 16 synchronized estrous Iranian Chall ewes were placed with fertile rams from the same breed. After mating these ewes were separated from the rams and ultrasonography program was performed. In order to assess the earliest time of pregnancy, ultrasonography was performed daily from the day 10 to 26 of mating, and twice a week from day 26 to 68, and once a week from day 68 until parturition for all ewes. Ultrasonography diagnosis was performed using intrauterine technique as well as transcutaneous. The earliest assessment of pregnancy was day 18 in which pregnancy could be diagnosed in two ewes. The best criterion pregnancy diagnosis in primary days of pregnancy was observation of embryonic vesicle by intrauterine ultrasonography. By increasing of gestational age some criteria such as Thoracic Depth(Dorsosventral diameter of thoracic cavity), Abdominal Depth(Dorsosventral diameter of abdominal cavity) and Intercostal Space were measured. Regarding to the results of the present study some morphometric values were gained by which the gestational age could be assessed in this breed.

**Key Words:** Ultrasonography, Pregnancy, Ewe

#### 1627 The effects of offering grass or maize silages with mineral lick supplementation to pregnant ewes on ewe performance and IgG absorption in the lamb. T.F. Crosby1, J.V. O’Doherty2, P. Nowakowski3, P.J. Quinn1, J.J. Callan1, B. Flynn1, D. Cunningham1, P. Reilly1, and D. Joyce3, 1University College Dublin, Faculty of Agriculture, Belfield, Dublin 4, Ireland, 2Agricultural University Wroclaw, Department of Sheep Breeding, Wroclaw, Poland.

Individually fed twin bearing ewes (n=64) were offered either grass or maize silage ad-libitum which was supplemented with 400g concentrates per day in addition to they having limited access (3.5-5 kg) to a molasses based mineral lick (ML) from day 92 of pregnancy until lambing, in order to evaluate the effects of the mineral lick supplementation on ewe performance and immunoglobulin (IgG) absorption in the lamb. Average daily ML intake was 84.3g and 93.7g for the grass and maize silages respectively. Forage DM intake was higher for the maize than for grass silage (1.11 vs 0.95 kg/ewe; SEM 0.037; P<0.005) and also when ewes had access to ML (1.10 vs 0.96 kg/ewe; SEM 0.037; P<0.01). A similar trend applied to protein intake. There was big increase in daily water intake when ewes had access to ML (3.7 vs 2.69 l/day; SEM 0.101; P<0.01). The ML treatment had no effect on ewe live weight change, but intake when ewes had access to ML (3.7 vs 2.69 l/day; SEM 0.101; P<0.01). The ML treatment had no effect on ewe live weight change, but ewe body condition score, gestation length, litter weight or the incidence of mal-presentations at lambing (P>0.05). When ewes had access to ML, colostrum yield tended to be higher at the 1h milking (598 vs 436 g/ewe; SEM 60.6; P<0.01) but there was no effect on the concentration of solids, crude protein or colostral IgG concentration (P>0.05). In contrast, lambs fed colostrum obtained from ewes on the ML treatment had significantly lower serum IgG concentration (6.8 vs 18.8 g/lit; SEM 1.48; P<0.05) and the percentage of IgG absorbed from the colostrum was also lower (9.71 vs 24.74; SEM 2.140; P<0.01). These data clearly show that when pregnant ewes have access to molasses based mineral licks in late pregnancy that water intake is considerably increased and the lamb has a dangerously lowered level of protective antibodies in the serum, so necessary to protect it from disease. Further research is needed to determine if the lowered IgG absorption is due to programming of the foetus in utero or is due to changed characteristics of the colostrum.

**Key Words:** Sheep, Colostrum, Immunoglobulin

#### 1628 Performance of St. Croix White and Dorper x St. Croix White lambs from birth to weaning in the tropics. R.W. Godfrey1, A.J. Weis, and R.E. Dodson, Agricultural Experiment Station, University of the Virgin Islands.

To evaluate the neonatal and pre-weaning performance of crossbred lambs under tropical conditions a Dorper (DRP) and a St. Croix White (STX) ram were bred to STX ewes (n = 12 and 14 ewes/sire, respectively). Ewes were maintained on guinea grass pastures (.4 ha) in a rotational grazing system from the start of breeding (June) through weaning (August/September). The 24-hr milk production of all ewes was measured on days 7, 21, 35, 49 and 63 (lambing = d 0). Ewes were given 1 IU of oxytocin (i.v.) and milked by hand and separated from their lambs. Four hours later ewes were hand milked, using oxytocin, and the milk was weighed to determine 24-h milk production. Total milk production was determined as the sum of 24-h milk production for each day of milking. Ewes were weighed weekly. Lambs were weighed at birth and at weaning at 63 d of age. Data were analyzed using GLM procedures of SAS. Dorper-sired lambs were heavier at birth (P<0.005) than STX-sired lambs (3.4 ± 0.1 vs 2.9 ± 0.1 kg, respectively). Lamb survival rate at birth, 1 wk of age or weaning was not different (P>0.10) between DRP and STX sire groups (100, 95.2 and 85.7 vs 100, 88.5 and 84.6 %, respectively). Ewe body weight at lambing was not different (P>0.10) between DRP and STX sire groups (41.1 ± 0.5 vs 41.1 ± 1.3 kg, respectively). Weaning weight of DRP lambs was greater (P<0.008) than STX-sired lambs (14.7 ± 0.4 vs 13.2 ± 0.4 kg, respectively). Ewe weight at weaning was not different (P>0.10) between DRP and STX sire groups (42.8 ± 1.6 vs 44.3 ± 1.6 kg, respectively). Milk production of ewes during the 63-d lactation was not different (P>0.10) between sire groups. There was no difference (P>0.10) in total milk production between DRP and STX bred ewes (4577 ± 324 vs 4507 ±

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<table>
<thead>
<tr>
<th>Item</th>
<th>AS</th>
<th>AAS</th>
<th>RCS1</th>
<th>RCS2</th>
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<td>23.7±</td>
<td>22.2±</td>
<td>21.5±</td>
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<td>0.66ab</td>
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<td>30.8ab</td>
<td>29.5ab</td>
<td>28.6b</td>
<td>0.8ab</td>
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<tr>
<td>Milk fat, kg/d</td>
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<td>1.25b</td>
<td>1.14b</td>
<td>1.10b</td>
<td>0.04ab</td>
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<tr>
<td>Milk protein, kg/d</td>
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<td>1.02b</td>
<td>0.94b</td>
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<td>1.1ab</td>
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<td>NDF digestibility, %</td>
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1Standard error of least square mean difference: a,b,c Means in rows without common superscripts are different (P<0.05)