	CS	CST	Diet SAHT	LAHT	AST	Statistical contrast ($P <$) A	B	C	D
DMI, kg/d	27.3	26.1	26.7	26.6	26.5	0.08	NS	NS	NS
Rumen pH	6.23	6.26	6.32	6.40	6.31	NS	0.02	0.03	NS
Milk, kg/d	44.9	44.3	44.8	44.3	43.6	NS	NS	NS	NS
Fat, kg/d	1.4	1.2	1.4	1.3	1.5	0.01	0.01	0.10	NS
Fat, %	3.1	2.7	3.2	3.0	3.3	0.01	0.01	0.03	0.10
trans-10 C18:1, %	0.8	2.2	1.0	1.7	0.8	0.01	0.01	0.01	NS

[1]A = CS vs. CST; B = CST vs. SAHT + LAHT + AST; C = SAHT vs. LAHT; D = SAHT vs. AST.

Key Words: Tallow, Milk fat, Alfalfa and particle length

584 Effects of feeding raw, micronized and extruded flaxseed on rumen fermentation parameters and nutrient utilization by lactating dairy cows. C. Gonthier*[1], A. F. Mustafa[1], D. R. Ouellet[2], R. Berthiaume[2], and H. V. Petit[2], [1]*Macdonald Campus of McGill University,* [2]*Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada.*

Four ruminally and duodenally cannulated multiparous lactating Holstein cows (average BW 595 ± 70 kg, average DIM 225 ± 35) were used in a 4 x 4 Latin square experiment to investigate the effects of feeding unheated, micronized and extruded flaxseed on nutrient utilization and ruminal fermentation parameters of dairy cows. Four diets were formulated; a control diet with no flaxseed (NF), an unheated flaxseed diet (RF), a micronized flaxseed diet (MF) and an extruded flaxseed diet (EF). The flaxseed diets contained 6% fatty acids while NF contained 3% fatty acids (DM basis). All diets were formulated to be isonitrogenous. Results showed that feeding flaxseed had no effect on DMI, ruminal pH or NH_3-N concentration. Duodenal flow of DM was lower ($P < 0.05$) for cows fed EF compared with the other dietary treatments. Cows fed EF had a higher ($P < 0.05$) ruminal degradability of DM, OM and gross energy and a lower ($P < 0.05$) ruminal degradability of fatty acid compare with those fed MF. Ruminal CP degradability was higher ($P < 0.05$) for cows fed EF than for those fed the other dietary treatments. Intestinal digestibility of DM and CP were higher ($P < 0.05$) for cows fed MF than for cows fed NF or EF. Feeding RF also increased ($P < 0.05$) intestinal digestibility of CP relative to feeding NF or EF. Whole tract DM, OM, CP and NDF digestibilities were all higher ($P < 0.05$) for cows fed flaxseed diets than for cows fed NF. No differenced in whole tract nutrient digestibilities were found between cows fed EF and those fed MF. We concluded that inclusion of flaxseed in dairy cow diets up to 2 kg of the diet DM increased whole tract nutrient utilization by dairy cows with no negative effects of ruminal fermentation. Micronization can be used to increase ruminal undegraded protein content in flaxseed while extrusion can be used to increased nutrient availability in the rumen.

Key Words: Flaxseed, Heat treatment, Nutreint utilization

585 Effects of rumen-inert fat saturation on feed intake, milk production, and plasma metabolites in lactating dairy cows. K. J. Harvatine* and M. S. Allen, *Michigan State University, East Lansing.*

Saturated (SAT) and unsaturated (UNSAT) rumen-inert fat sources were evaluated for effects on feed intake, milk yield, and plasma metabolites. Eight ruminally and duodenally cannulated multiparous Holstein cows (77± 12 DIM) were used in a duplicated 4x4 Latin square design with 21 d periods. Treatments were control (CON) and a linear titration of 2.5% added rumen-inert fatty acids (FA) varying in unsaturation; SAT (prilled FA, Energy Booster 100®), 50:50 ratio of SAT and UNSAT (calcium soaps of long chain FA, Megalac R®), and UNSAT. Experimental diets were 40% forage and contained 27.5% NDF, 30% starch and 2.5% FA from supplemental vegetable fat (14% cottonseed). Fat treatments increased gross energy (GE) of the diet 8.2%. Increasing fat saturation increased milk yield 2.9 kg/d, however there were no treatment effects of concentration or type of fat on 3.5% FCM, SCM or energy corrected milk. Yield of milk components and milk composition were not affected by treatment. Negative effects of fat supplementation on DMI increased linearly as UNSAT increased (25.8, 24.5, 24.1, 23.0 kg/d for CON, SAT, 50:50, and UNSAT, respectively). Dry matter intake for SAT was not different from control while UNSAT decreased DMI relative to control ($P < 0.05$). UNSAT linearly decreased DMI up to 1.5 kg/d ($P < 0.05$) and tended to decrease GE intake up to 3.94 Mcal/d ($P <0.10$) compared to SAT. Wet weight of rumen contents tended to decrease 8.9% with rumen inert fat treatments compared to CON ($P < 0.1$) and decreased linearly by UNSAT compared to SAT ($P < 0.05$). Plasma NEFA, BHBA and glucose also were not affected by level or type of fat. UNSAT linearly increased empty body weight gain up to 0.84 kg/d ($P = 0.01$) and NE_L gain 3.9 Mcal/d calculated from empty body weight ($P = 0.02$) compared to SAT. Fat supplementation with rumen-inert fat sources had no effect on milk yield or composition but type of fat affected DMI and tissue energy gain.

Key Words: Rumen-inert fat, Saturation, Hypophagic effects

586 Interrelationships of hepatic palmitate and propionate metabolism, liver composition, blood metabolites, and cow performance. M. S. Piepenbrink* and T. R. Overton, *Cornell University, Ithaca, NY.*

Measurements (n=27) from 95 cows in previous experiments conducted in our laboratory were used to evaluate the potential relationships between liver triglyceride content (TG), liver metabolism, blood metabolites, and cow performance. Initially, data was subjected to Pearson correlation analysis. Those variables that were significantly ($P < 0.05$) correlated with TG on d1 and 21 postpartum were used to develop equations for predicting liver TG content. Variables were removed from multiple regression analysis in a stepwise, backward fashion until all variables had a probability of a greater $F < 0.05$. For TG on d1 postpartum, the TG 21d prepartum, the capacity of liver to store [1-^{14}C]palmitate intracellularly (SEP) 21d prepartum, the capacity of [1-^{14}C]propionate conversion to CO_2 (POx) on d1 postpartum, the area under the curve for concentration of NEFA in plasma from d7 prepartum to d21 postpartum (NAUC), and the area under the curve for βHBA from d7 prepartum to d21 postpartum (BAUC) remained significant resulting in the equation TG_1 ($r^2 = 0.61$). For TG on d21 postpartum, TG on d21 prepartum and d1 postpartum, capacity of liver to convert [1-^{14}C]propionate to glucose 21d postpartum (GNG), calving body condition score (BCS_c), and NAUC were significant resulting in the development of the equation TG_{21} ($r^2 = 0.51$). Other correlations suggested relationships between TG and GNG (r = -0.39 and #0.48 for d1 and d21), cumulative DMI from d-7 to +21 (r= -0.37 and #0.35 for d1 and d21), BCS_c (r = 0.29 and 0.36 for d1 and d21) and BW change from calving to 3 wk postpartum (r = -0.33 and #0.34 for d1 and d21). These findings reemphasize the importance for optimal BCS for cows at calving to reduce the severity of fatty liver and confirm the negative relationship between liver TG accumulation and gluconeogenic capacity.

$TG_1 = -8.6245 + (1.8047 \times TG\text{-}21) + (0.0284 \times SEP) - (0.0006 \times POx) + (0.0002 \times NAUC) + (0.0041 \times BAUC)$

$TG_{21} = -26.4965 + (2.1958 \times TG\text{-}21) + (0.4472 \times TG1) + (0.0014 \times GNG) + (6.6574 \times BCS_c) + (0.0005 \times NAUC)$

Key Words: Periparturient cow, Liver

Ruminant Nutrition: Additives, enzymes and feedstuff analysis

587 Effects of cinnamaldehyde, garlic and monensin on nitrogen metabolism and fermentation profile in continuous culture. M. Busquet[1], S. Calsamiglia*[1], A. Ferret[1], and C Kamel[2], [1]*Universidad Autonoma de Barcelona, Spain,* [2]*University of Leeds, UK.*

Eight 1.3-L dual flow continuous culture fermenters were used in three 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 50-50 forage-to-concentrate diet. Treatments were: no additive (Negative Control, NC), Monensin (4 or 40 mg/d per fermenter, M and M10), Cinnamaldehyde (100 or 1000 mg/d per fermenter, CI and CI10) and Garlic (100 or 1000 mg/d per fermenter, G and G10). 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 peptide N (Pep-N), aminoacid N (AA-N), ammonia N (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 Pep-N, AA-N and NH3-N concentrations. Data were analyzed using the PROC MIXED (SAS, 1996) and significance declared at $P < 0.05$. Total VFA (mM) was higher in M10 (128.7) compared with NC (119.0). Acetate proportion (mol/100mol) was lower for CI (58.6), G (59.6), G10 (48.3) and M10 (46.1) compared with NC (63.1). Propionate proportion (mol/100mol) was higher in CI (23.6), G10 (27.1) and M10 (45.3) compared with NC (19.8). Butyrate proportion (mol/100mol) was higher in G10 (18.3) and lower in M10 (4.1) compared with NC (10.3). The Pep-N concentration across all hours (mg/100ml) was similar in all treatments. The AA-N concentration across all hours (mg/100ml) was higher in G10 (4.6) and M10 (4.4) compared with NC (1.9). The NH3-N concentration across all hours (mg/100ml) was lower in M10 (13.0) compared with C (19.2). The CI and G10 modified propionate and acetate proportions in the same direction as M10. However, the higher proportion of butyrate observed in G10 compared with M10 suggests a different mechanism of action may be involved. The accumulation of AA-N, and the decrease in NH3-N in M10 suggests that deamination was inhibited.

Key Words: Rumen fermentation, Monensin, Cinnamaldehyde

588 Malate in concentrate improves growth performance and digestibility of intensively fattened lambs.

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Malate (Rumalato®; Norel & Nature) as a feed additive was evaluated in a total of 76 Manchega and Lacaune lambs. After weaning (35 d of age), lambs were allotted in balanced groups and fed ad libitum with a pelletized concentrate (18.2% CP; 1.82 Mcal NE/kg, DM basis) and chopped barley straw. Four types of concentrate were prepared according to the inclusion of malate (0.2% in concentrate) and type of cereal (barley or corn). Treatments were: B (barley); BM (barley-malate); C (corn); and, CM (corn-malate). In Exp. 1, 64 lambs (16.4 kg BW) were kept in straw bedded pens and used in a 2×2 factorial design with two repetitions to evaluate growth performances and rumen traits at slaughtering (26 kg BW). In Exp. 2, the same diets were used in 12 male lambs (14.9 kg BW) to study the nutrient digestibility in a 4×4 Latin square design. Eight lambs (two per diet) were randomly assigned to each treatment and kept in metabolic crates for four periods of 21 d. The remaining lambs were maintained as a reserve group. Malate improved fattening performance, ruminal pH and mucosa traits in Exp. 1, but days at slaughtering (32 d) did not vary. In Exp. 2, digestibility of nutrients and energy also increased by effect of malate. Concentrate type had less effect than malate. Use of Rumalato® (0.2%) is recommended as a feed additive in intensively fed lambs. Results (LSM means) of both experiments were:

Item	Treatments				Effects (P<)	
	B	BM	C	CM	Malate	Concentrate
Exp. 1 (n=64)						
ADG, g/d	259^b	330^a	299^{ab}	307^{ab}	0.013	0.616
DMI, kg/d	0.948^a	0.923^a	0.913^a	0.844^b	0.007	0.047
Feed conversion rate	3.80^a	2.87^b	3.25^b	2.90^b	0.002	0.240
Ruminal pH	6.87^b	7.05^{ab}	6.93^{ab}	7.13^a	0.017	0.320
Exp. 2 (n=8)						
Digestibility, %						
DM	78.1^b	82.1^a	79.3^b	83.1^a	0.001	0.399
OM	81.0^b	84.5^a	82.2^b	85.6^a	0.001	0.288
CP	78.3^b	82.2^a	76.1^b	81.2^a	0.001	0.237
NDF	39.8^b	49.7^a	42.1^b	48.6^a	0.001	0.491
ADF	47.4^b	55.9^a	54.9^a	59.2^a	0.017	0.007
GE	80.6^b	83.4^a	81.4^b	84.5^a	0.003	0.344

^{a,b}: P<0.05

Key Words: Malate, Feed additives, Digestibility

589 Effects of fibrolytic enzyme supplementation on the performance of growing cattle fed bermudagrass hay and molasses-based liquid supplements.

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One hundred and sixty Angus x Brahman crossbred yearling steers and heifers (initial BW=285 kg) were utilized to study the effects of five commercially available fibrolytic enzymes (cellulase, xylanase, beta-gluconase) on weight gain in growing cattle. All calves received a basal diet of bermudagrass hay (ad libitum, average intake 6.22kg/d) and 2 kg DM/d sugar cane molasses supplement, containing urea, vitamins and minerals. Calves were randomly assigned by sex and breed type to 32 pastures (0.8 ha, four pastures/treatment) with five cattle per pasture. Treatments included the basal diet fed without (Control) or with the following enzyme supplements: 1.5 or 3 g/d of Cattle-ase HR (CAT), or 0.12 g/d of Biocellulase A20 (A20), or 0.12 g/d of Biocellulase A20 and 0.06 g/d of Biocellulase X20 (A20/X20), or 2 or 4 g/d of Promote N.E.T.™ (PRO), or 15 g/d of Fibrozyme® (FIB). Additionally, the effects of a methionine hydroxy-analog (Alimet®) were examined by splitting each treatment group in half (two pastures), with one half receiving 12.5g /d Alimet® in the molasses supplement and the other half not receiving Alimet®. Trial duration was 113 days (December 12, 2001-April 2, 2002). Data were analyzed using the PROC Mixed function of SAS. Supplementation with fibrolytic enzymes had no effect (P=0.62) on gains as compared to control (0.49 kg/d vs. 0.50 kg/d). Cattle weight gains did not express a treatment by Alimet® interaction (P=.91). Supplementation of cattle with Alimet® had no effect (P=.58) on weight gains as compared to unsupplemented cattle (.50 kg/d vs. 0.49 kg/d). Supplementation with A20 and A20/X20 tended to increase (P=.08) gains over cattle supplemented with CAT at 1.5 g/d and 3 g/d (.54 kg/d vs. .47 kg/d). Supplementation with A20 and A20/X20 increased (P=.05) gains over cattle supplemented with PRO at 2 g/d and 4 g/d (.54 kg/d vs. .46 kg/d). Supplementation with enzymes had no effect (P=.50) on change in height as compared to control (6.62 cm vs. 5.98 cm). Supplementation of growing cattle with fibrolytic enzymes had no effect on animal performance as compared to control.

Key Words: Beef Cattle, Enzymes, Supplementation

590 Effect of fibrolytic enzyme preparations containing esterase, cellulase, and endogalacturonase activity on the digestibility of mature, tropical grass hays.

N. Krueger*, D. Dean, W. Krueger, C. Staples, and A. Adesogan, [1]*University of Florida, Gainesville, FL USA.*

This study examined the effect of applying an enzyme complex (Depol 670L, Biocatalyst, UK) containing high esterase (7 U/ml), cellulase (1200 U/g), and endogalacturonase (800 U/g) activities on the digestibility of three tropical grass hays. The enzyme was applied in liquid form at 0, 0.5, 1, 2, or 3 (g/100g DM) to hay produced from 12-wk regrowths of Common bahiagrass (B) (*Paspalum notatum*), Coastal bermudagrass (C) (*Cynodon dactylon*), and Tifton 85 bermudagrass (T)(*Cynodon dactylon*)24h before in vitro digestion. Substrates were incubated in triplicate for 6, 24, and 48 h in buffered, ruminal fluid within Ankom Daisy II incubators. Treatments were arranged in a 3 x 5 factorial design with each hour of incubation analyzed separately. The experiment was repeated three times and ruminal fluid used was collected from two cows fed bermudagrass hay supplemented with 0.4 kg/d of soybean meal. Increasing the enzyme application rate resulted in a quadratic increase (P = 0.005) in IVDMD of B (135, 155, 169, 188, and 177 g/kg), C (175, 195, 204, 205, and 224 g/kg), and T (103, 110, 121, 143, and 145) hays at 6 h and in a linear increase (P = 0.007) in IVDMD of B (493, 501, 513, 520, and 521 g/kg), C (479, 487, 495, 504, and 512 g/kg), and T (486, 478, 481, 508, and 506 g/kg) at 48 h. Increasing enzyme application rate also resulted in quadratic increases (P = 0.001) in NDF digestibility (IVNDFD) of B (15, 26, 53, 37, and 36 g/kg), C (46, 41, 51, 38, and 59 g/kg), and T (19, 17, 30, 41, and 33 g/kg) at 6 h. At 6 h, optimum IVNDFD for B was at the 1% application rate but that for the C and T hays was at the 3 and 2% rates respectively (B vs. (C + T) by quadratic interaction (P = 0.030) and C vs. T by quadratic interaction (P = 0.076)). The main effect of enzyme addition on IVNDFD at 24 and 48 h was not significant. This work demonstrates the potential of fibrolytic enzymes for enhancing the digestion of tropical grass hays.

Key Words: Tropical grass, Esterase, Cellulase

591 Effect of fibrolytic enzyme preparations containing high esterase activity on the digestibility of mature, tropical grass hays.

N. Krueger*, D. Dean, W. Krueger, C. Staples, and A. Adesogan, *University of Florida. Gainesville, FL USA.*

This study examined the effect of applying an enzyme preparation (Depol 740, Biocatalyst, U.K.) containing high esterase (32 U/ml) activity

on the in vitro digestibility of three tropical grass hays. The enzyme was applied at 0, 0.5, 1, 2, and 3 (g/100g DM) on the in vitro digestion of hay produced from 12-wk regrowth of Common bahiagrass (B), Coastal bermudagrass (C), and Tifton 85 bermudagrass (T) 24 h before in vitro digestion. Forages were incubated in triplicate for 6, 24, and 48 h in buffered, ruminal fluid within Ankom Daisy II incubators. Treatments were arranged in a 3 x 5 factorial design with each hour of incubation analyzed separately. The experiment was repeated three times and ruminal fluid used was collected from two cows fed bermudagrass hay supplemented with 0.4 kg/d of soybean meal. The IVDMD of B (133, 159, 165, 156, and 182 g/kg), C (180, 185, 178, 207, and 212 g/kg) and T (99, 113, 97, 149, and 159 g/kg) at 6 h increased linearly (P = 0.001) as the enzyme application rate increased. The increase in IVDMD at the 2% application rate was greater for T compared to C (C vs. T by quadratic interaction, P = 0.018). Likewise, the IVDMD of C at 48 h tended to increase linearly as enzyme application increased (487, 484, 489, 506, and 510 g/kg) but that of T at 48 h was unaffected (485, 481, 478, 485, and 497 g/kg) (C vs. T by linear interaction, P = 0.069). The NDF digestibility (IVNDFD) of T at 6 h (41, 34, 29, 61, and 72 g/kg) increased linearly with increasing enzyme addition whereas that of C (56, 58, 41, 75, and 63 g/kg) did not increase (C vs. T by linear interaction, P = 0.011). The IVNDFD of B at 24 h (325, 310, 330, 270, and 373 g/kg) increased linearly whereas that of C (305, 280, 299, 300, and 284 g/kg) and T (310, 338, 304, 337, and 331 g/kg) were unaffected by increasing enzyme addition (B vs (C + T) by linear interaction (P = 0.036). In conclusion, the enzyme enhanced the digestion of the hays but the pattern and extent of the improvement was forage specific.

Key Words: Tropical grass, Esterase, Digestion

592 The potential for enhancing the digestion of C4 grass hays with proprietary fibrolytic enzymes. D. Dean*, N. Krueger, L. Sollemberger, and A. Adesogan, [1]*University of Florida, Gainesville, FL/USA*.

This trial examined the effect of applying four proprietary cellulase/hemicellulase enzymes on the digestibility of two tropical grasses. Promote (P), Biocellulase X-20 (X), Cattle-Ase (CA) and Biocellulase A-20 (A), were applied at: 0, 0.5x, 1x and 2x the recommended rates on hays produced from 12 week regrowths of Coastal bermudagrass (BE) (*Cynodon dactylon*) and Common bahiagrass (*Paspalum notatum*) (BA) and the hays were stored for three weeks. In vitro digestibility of dry matter (IVDMD) and neutral detergent fiber (IVNDFD) were calculated after digesting the hays in buffered rumen fluid for 6 or 48 h in two ANKOM^{II} Daisy Incubators. Separate randomized complete block designs were used to quantify the effects of enzyme application on each hay at each period. Increasing the enzyme application rate produced linear and quadratic increases (P<0.01) in 6h IVDMD in BE hays treated with X (72.1, 89.6, 98.5 and 93.4 g/kg) and A (72.1, 121.8, 137.5 and 119.5 g/kg), and linear increases (P<0.01) in BE hays treated with CA (72.1, 75.9, 88.2 and 91.6 g/kg) at 6h and X at 48 h (410.3, 501.7, 518.9 and 534.2 g/kg) respectively. As enzyme application increased, IVNDFD was increased (P<0.01) linearly in BE hays treated with P at 6 h (41.0, 47.8 56.9 and 70.2 g/kg) and 48 h (429.9, 460.9, 442.8 and 492.1 g/kg) but a linear decrease (P<0.05) occurred in BE hays treated with CA at 48 h. BA hays treated with CA (129.6, 122.2, 112.3 and 144.8 g/kg) had linear (P<0.05) increases in 6h IVDMD as enzyme application increased, but a cubic (P<0.05) response was observed in BA hays treated with A at 48 h. There was a quadratic (P<0.05) increase in 6h IVNDFD of BA hays treated with P, and a linear increase (P<0.05) in that of BA hays treated with A. There were also cubic (P<0.05) responses in the 48h IVNDFD of BA hays treated with P and A at 48 h. This work shows that some fibrolytic enzymes complexes can enhance digestion of C4 grasses. However, improvements vary with digestion stage and forage type.

Key Words: Enzymes, Digestibility, C4-grasses

593 Effects of dietary sodium bicarbonate and sodium chloride on ruminal pH and digesta characteristics in dairy cows. C. S. Mooney* and M. S. Allen, *Michigan State University, East Lansing*.

Six ruminally and duodenally cannulated, mid-lactation (176 ± 12 DIM, mean ± SD) Holstein cows were used in a duplicated 3 x 3 Latin square design to evaluate effects of sodium bicarbonate on ruminal characteristics. Periods were 28 d in length with the last 14 days for data and sample collection. Treatments were control, sodium bicarbonate at 1% of dietary DM, and an isomolar concentration of sodium chloride. Each diet contained a common base mix (95% of diet DM) to which treatment premixes (5% of diet DM) were added. The control premix was composed of 50% finely ground dry corn and 50% ground rice hulls on a DM basis. Sodium bicarbonate and sodium chloride were included in place of rice hulls in their respective premixes. Diets were formulated to 20% forage NDF and 17.5% CP. Ruminal pH was measured every 5 seconds for 5 days by indwelling pH probes. Mean ruminal pH was 6.2 and was not affected by treatment (P= 0.97), nor was any other measure of pH (minimum, maximum, range, standard deviation, or time or area under pH 5.5, 5.8, or 6.0; $P > 0.28$). Dry matter intake and 3.5% FCM were similar across treatments (23.8 and 35.7 kg/d, respectively). Mean milk fat concentration was 3.51% and was not affected by treatment. Both sodium treatments increased water intake compared to control (103.8 vs. 98.6 L/d, italicizeP = 0.05) but there was no difference between sodium treatments ($P = 0.83$). Volume of rumen contents was increased by sodium bicarbonate compared to control (102.8 vs. 90.3 L, $P = 0.02$) but not by sodium chloride ($P > 0.50$). Density of ruminal contents was greater for sodium chloride compared to sodium bicarbonate (0.87 vs. 0.81 kg/L, $P < 0.01$). Differences in effects of the two sodium treatments on ruminal digesta volume and density might be because of their osmotic effects on water and DM turnover in the rumen. Lack of effect of sodium bicarbonate on ruminal pH or milk fat concentration was probably because buffering capacity of bicarbonate was in excess for all treatments.

Key Words: Sodium bicarbonate, Sodium chloride, Ruminal characteristics

594 Feeding fibrolytic enzymes to enhance DM and nutrient digestion, and milk production by dairy cows. P. Mandebvu*[1], C. S. Ballard[1], M. P. Carter[1], K. W. Cotanch[1], C. J. Sniffen[1], T. Sato[2], K. Uchida[2], A. Teo[3], U. D. Nhan[3], and T. H. Meng[3], [1]*W. H. Miner Agricultural Research Institute, Chazy, NY,* [2]*ZENNOH National Federation of Agricultural Co-operative Associations, Tokyo, Japan,* [3]*Kemin Industries (Asia), Pte, Ltd, Singapore*.

Forty-two multiparous Holstein cows (60-180 days in milk) housed in a free-stall barn were blocked by parity and previous 305-d mature equivalent milk production, and randomly assigned to a control TMR or a TMR containing fibrolytic enzymes in a study with a crossover design with two 28-d periods. The enzymes contained primarily cellulase, xylanase and neutral protease activities, and were added as a dry powder to the concentrates prior to addition of forages in the mixer wagon. Enzymes were applied at the rate of 1g/kg of non-forage DM of the Enzyme TMR. TMR comprised of 47-48% forages and 52-53% concentrates, and contained 18% CP and 31-33% NDF. Cows were group-fed by treatment and DM intake for each pen was recorded. During the fourth week of each period, milk production was recorded from all cows, and total tract digestion measured from a subset of animals using chromic oxide as an external marker. Fibrolytic enzymes enhanced digestion of DM, OM, and nonfiber carbohydrates ($P < 0.05$), but had no effect on digestion of CP and fiber or milk yield and composition.

Item	Control	Enzyme	SE	P-value
DMI[1], kg/d	26.7	27.1	...	...
Total tract digestibility, %				
DM	66.6	69.4	0.70	0.027
OM	67.4	70.0	0.74	0.047
CP	62.1	63.3	0.95	0.412
ADF	42.5	42.5	1.39	0.987
NDF	44.1	43.8	1.18	0.904
Hemicellulose	41.1	43.8	2.70	0.511
Cellulose	49.4	48.2	2.03	0.689
Fat	83.1	84.3	0.64	0.228
NFC[2]	89.1	91.4	0.44	0.015
Lactational Performance				
Milk yield, kg/d	43.3	43.3	0.40	0.955
3.5% FCM yield, kg/d	43.6	43.2	0.60	0.641
Milk fat, %	3.57	3.51	0.062	0.550
Milk true protein, %	2.81	2.80	0.009	0.543
Milk lactose, %	4.84	4.84	0.012	0.676
Milk urea N, mg/dl	14.5	14.8	0.25	0.374
SCC[3] x 1000	132.1	99.4	21.20	0.282

[1]Average pen DM intake of group-fed animals. [2]Nonfiber carbohydrates = 100-(ash + NDF + CP + fat). [3]Somatic cell count.

Key Words: Dairy cow, Fibrolytic enzymes, Digestion and milk yield

595 Effect of pH and enzyme supplementation to a total mixed ration on microbial fermentation in continuous culture. D. Colombatto*[1,2], G. Hervas[3], W. Yang[1], and K. Beauchemin[1], [1]*Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada,* [2]*Facultad de Agronomia, Universidad de Buenos Aires, Argentina,* [3]*Estacion Agricola Experimental (CSIC), Leon, Spain.*

The effects of pH and enzyme addition were examined in continuous culture using a 4 x 4 Latin square design, with four 9-d periods consisting of 6 d for adaptation and 3 d for measurements. The buffer pH was adjusted to 100% (high) or 60% (low) of the normal concentration of artificial saliva. Fermenters were fed twice daily a diet consisting of 30% alfalfa hay, 30% corn silage, and 40% rolled corn (DM basis). The silage was milled fresh and the TMR was fed fresh to the fermenters (64% DM). The EM was a protease containing no other major activities, and was applied daily to the TMR, at least 12 h before feeding. Treated feed was stored at 4°C until fed. Ranges of pH were 6.0-6.6, and 5.4-6.0 for high and low, respectively. Degradability of OM, NDF, ADF, and cellulose were reduced ($P < 0.05$) by low pH, but hemicellulose and protein degradation were not affected. EM addition increased ($P < 0.01$) NDF degradability (by 43% and 25% at high and low pH, respectively), largely due to an increase in hemicellulose degradation (by 79% and 51%, respectively). Total volatile fatty acids (VFA) and its molar proportions were decreased ($P < 0.05$) by low pH, but were not affected by EM. Protein degradation was only numerically ($P = 0.17$) increased by EM. Total N flow tended ($P = 0.07$) to be reduced with EM, but neither bacterial nor dietary N flow was affected by the treatments. Microbial protein synthesis was not affected by either pH ($P = 0.29$) or EM ($P = 0.86$). Methane production, expressed as a proportion of total gases, was decreased ($P < 0.001$) at low pH, but was not affected by EM. It is concluded that it is possible to adapt the CC system to use fresh feeds instead of dried feeds. Overall, the results indicate that the EM used in this study has significant potential to increase fiber degradability without increasing methane production.

Key Words: Continuous culture, Digestion, Enzymes

596 Effect of the sequence of fat and antibiotic-ionophores on ruminal fermentation and microbial lipids. M. G. Daves* and V. Fellner, *North Carolina State University, Raleigh, NC.*

Rumen inoculum was obtained from a fistulated cow, filtered, and incubated in 8 dual-flow fermentors. The basal diet consisted of 100 % alfalfa pellets and was offered twice daily (14g DM/d). Cultures were allowed two days of adaptation and then used to test the sequence effects of fat, monensin, and bacitracin addition. On day 3, two fermentors received monensin, two received bacitracin, and the other four received fat. On day 6, fat was added to the cultures receiving monensin and bacitracin, and two of the four fermentors fed fat were offered monensin and the other two bacitracin for an additional three days. A total of four replications were conducted. Data were analyzed using the Mixed procedure of SAS for repeated measurements. Monensin reduced methane 15% and 23% when compared to fat and bacitracin, respectively. Adding monensin prior to fat lowered methane by 22% compared to the addition of fat prior to monensin. Monensin increased ($P < 0.01$) propionate compared to bacitracin but increased valerate ($P < 0.03$) and iso-valerate ($P < 0.0001$) compared to fat. Addition of monensin prior to fat increased ($P < 0.03$) valerate when compared to cultures that received fat prior to monensin. Fat increased ($P < 0.003$) isobutyrate compared to monensin. Isobutyrate was higher in cultures that received bacitracin prior to fat than those that received fat first. Monensin increased ($P < 0.01$) C16:0 compared to fat. Levels of C18:0 ranged between 23mg/g of total FA (monensin) to 30 mg/g of total FA (fat), but the difference was not significant. Cultures receiving monensin had lower concentrations of C18:0 than those receiving bacitracin, but the sequence of fat addition had no effect. The addition of additives and their sequences did not alter total or trans-C18:1 levels. Monensin increased ($P <0.05$) cis-C18:1 compared to bacitracin or fat. When monensin was added prior to fat cis-C18:1 was higher ($P <0.05$) than when fat was added prior to monensin. Monensin, either alone or when added prior to fat, was more effective in altering fermentation compared to bacitracin. Inclusion of fat prior to monensin or bacitracin altered the response to the ionophore-antibiotics.

Key Words: Ionophore-antibiotics, Fat, Continuous cultures

597 Comparison of different starch analysis methods for feedstuffs. K.-H. Suedekum*[1], M. B. Hall[2], and M. Paschke-Beese[1], [1]*University of Kiel, Germany,* [2]*University of Florida, Gainesville.*

The official EU method for starch analysis on feedstuffs is a polarimetric procedure utilizing the optical activity of dispersed starch. For pure starches and high-starch commodities, this method provides reliable and accurate results. When applied to feedstuffs low in starch and high in fiber or protein, reliability is considerably reduced and values often overestimate true starch values. The objective of this work was to compare the polarimetric method with different enzymatic procedures. All enzymatic procedures involved a preliminary digestion step with a heat-stable α-amylase (Termamyl 120 L), dissolved either in a Na-citrate buffer at pH 5.8 or in water, and release of glucose by action of amyloglucosidase in a Na-acetate buffer at pH 4.6. Glucose was quantified subsequently using either phosphorylation or oxidation to gluconic acid. Free glucose was determined in a separate assay to yield unbiased estimates of glucose from starch. Eleven test samples were utilized comprising low-starch (distillers' grains, soybean meal, citrus pulp, total mixed ration with 25% citrus pulp) and high-starch (corn starch, potato starch, hominy feed) commoditites. As a general observation, starch values determined polarimetrically (mean, 48.9% of dry matter) were higher ($P < 0.0001$) than those determined enzymatically (mean, 43.1% of dry matter). Comparisons among enzymatic procedures showed that Na-citrate buffer as an incubation medium for the α-amylase yielded higher starch values than water (44.4 versus 40.5% of dry matter; $P < 0.0001$). Type of quantification of glucose (phosphorylation versus oxidation to gluconic acid) gave the same average starch concentration (43.1% of dry matter; $P = 0.7846$). Results from this study indicate that Na-citrate buffer was better than water as an incubation medium for α-amylase, and that glucose released by α-amylase plus amyloglucosidase action can be quantified by phosphorylation or oxidation. Differences between polarimetric and enzymatic methods, and variation among enzymatic procedures require further investigation.

Key Words: Starch, Feed analysis, Methods

598 A novel technique to assess particle distribution of rations and forages using digital imaging. A. Bach*[1], A. Anglada[1], X. Puigvert[2], and L. Bosch[2], [1]*ICREA-IRTA Dairy Systems, Spain,* [2]*Universitat de Girona, Spain.*

The objective of this study was to develop a simple and efficient technique to determine particle size distribution of forages and total mixed rations (TMR) for dairy cattle using digital imaging. The particle size distribution of different rations from different dairy farms was evaluated using the Penn State Separator and the new digital image technique. The new technique is based on a digital picture from a small sample (about 500 g) of forage or TMR on a black surface. Afterwards, the picture is analyzed with software for digital measurements to determine the length and the area of most of the particles in the picture. Following the analysis, a distribution chart is constructed. The preliminary results indicate that both, the average area of the particles determined digitally and the average particle size determined with the Penn State Separator were correlated with milk fat percentage. However, the correlation was stronger when the particles were analyzed using digital measures ($R^2 = 0.26$; $P = 0.09$) than when using the Pen State Separator ($R^2 = 0.07$; $P = 0.43$). Therefore, digital imaging is a more precise method to estimate the consequences of particle size distributions of TMR on milk fat percentage. The advantage of using digital imaging vs the Penn State Separator is that the former provides reliable results even with wet TMR. In several occasions, the Penn State Separator failed with wet TMR because a fraction of the small particles remained attached to larger particles with greater water content. Therefore, to obtain reliable results with the Penn State Separator with high-silage TMR, the determination should be conducted on a dry sample. The use of digital imaging does not require drying the sample prior to particle evaluation. Also, digital imaging provides an entire distribution pattern of almost all the particles in the TMR, instead of only the three break points (1.18, 8, 19 mm) that the Penn State Separator yields. This technique

proved to be reliable, repeatable, and simple, and warrants future field application.

Key Words: Particle size, Forage, Total mixed ration

599 Comparison of three systems to estimate the fraction of non-fiber carbohydrate, and its ruminal digestibility, in common feedstuffs. A. Offner* and D. Sauvant, *INA P-G INRA, Paris, France*.

The objective of this study was to compare the prediction of the non-fiber carbohydrate content and ruminal digestibility by three systems for the estimation of feed values (CNCPS, NRC and INRA models). The comparison was based on twenty common feedstuffs. The fraction of non-fiber carbohydrate (**NFC**, % of DM) and the fraction of digestible NFC (**dNFC**, % of DM) were determined with the three systems. The NRC used an empirical approach to estimate dNFC: dNFC = 0.98 × PAF × (NFC + NDICP); with PAF, the processing adjustment factor, and NDICP, the neutral detergent insoluble protein. The CNCPS and INRA considered a more mechanistic approach of rumen digestion based on the "competition" between degradation and passage; the fractional passage rate was set at 6 % h^{-1}. The fractional degradation rates were from *in vitro* (CNCPS) and *in situ* studies (Offner et al., 2003). The results showed close correlations (r > 0.88) between the NFC fractions predicted by the three systems. However, the CA fraction defined in the CNCPS was not accurately linked to sugar (difference: +1.9, correlation: *NS*) or soluble NFC (-17.4, r = 0.62). In addition, the CB1 fraction was not accurately linked to starch (-2.6, r = 0.92) or degradable NFC (+15.9, r = 0.87). Results for the dNFC fraction outlined significant differences ranging from 1.5 to 31 % of DM among the three systems. The NRC significantly overestimated dNFC compared to CNCPS (+10.8, r = 0.88) and INRA (+12.0, r = 0.93). Moreover, the NRC and the CNCPS did not take into account all the variability observed in NFC digestibility when various processing treatments were applied. Differences among the three systems were surprising and indicated the need for a more consistent estimation of NFC and dNFC. This will perhaps be possible by integrating enough NFC sub-fractions, like those for starch, into the systems.

Key Words: Non-fiber carbohydrate, Rumen digestion, Feeding systems

600 Near infrared reflectance spectroscopy prediction of digestion rates for cereal grains. C. Lanzas* and A. N. Pell, *Cornell University, Ithaca, NY*.

Near infrared reflectance spectroscopy (NIRS) is used for commercial feed analysis because of its speed and precision. NIRS calibrations for digestion rates would be a step towards the field use of models that require digestion rates as inputs. Our objective was to assess the accuracy of NIRS in predicting digestion rates of dried cereal grains obtained by measurement of gas production. Eighteen barley, 99 corn, 23 sorghum, and 57 wheat samples were collected from 22 countries. Samples were ground to pass a 4-mm screen and fermented in vitro with rumen fluid for 48 hours. Gas production was measured with a computerized system and the data were fit to an exponential model to derive the fractional rates. The mean and SD of gas production rates were 0.24±0.029 h^{-1} for barley, 0.14±0.025 h^{-1} for corn, 0.06±0.015 h^{-1} for sorghum, and 0.26±0.038 h^{-1} for wheat. Samples were scanned from 1100 to 2498 nm with a visible/near-infrared scanning monochromator machine at 1 nm intervals. Modified partial least squares regressions were used to calibrate spectral data against gas production rates. Two calibration models were developed with the same data set. In the first model, 189 samples were used to develop the calibration model; the coefficient of determination was 0.89, and standard error of cross-validation (SECV) was 0.023 h^{-1}. In the second model, 98 samples were used to develop the calibration model, the remaining samples (n= 91) were used as a validation set. The coefficient of determination was 0.84, and standard error of validation (SEV) was 0.03 h^{-1}. For the validation set, SEV was partitioned into three orthogonal components: lack of correlation, bias, and non-unity slope. The error distribution was 88.8 % for lack of correlation, 11.2 % for the bias component and 0 % for the non-unity slope. The coefficients of determination of the models suggest that NIRS had the ability to predict digestion rates. However, the ratio between SD and SECV (2.8) indicated lower prediction ability of the equations compared with NIRS models for chemical fractions.

Key Words: Near infrared reflectance spectroscopy, Digestion rates, Gas production

Contemporary Issues Symposium: Designing animal experiments for power

601 Designing trials to test the bio-equivalency of treatments for animal performance. Ian McMillan*[1], [1]*University of Guelph, Animal and Poultry Science*.

When analyzing the results of a trial that has been conducted to compare treatments, it is usually the desire of the researcher to demonstrate a significance result for the contrasts of the group means that are of interest. This is certainly the case when an improved product is desired. However, in establishing the bio-equivalence of a test product to a standard, the objective is usually to conclude, with reasonable justification, that no difference has been detected. In making such determinations, the probabilities of accepting false hypotheses of equality, or those of rejecting correct hypotheses of difference must be taken into account. Prior to beginning the trial, the researcher should have a good estimate of the power that will be associated with the detection of a given maximum acceptable difference. The required sample size for achieving the desired power for these tests depends, among other things, upon the coefficient of variation (CV) in the data collected. The lower the CV, the smaller the detectable difference becomes. A reduced CV can be achieved, in some cases, by using an appropriate experimental design to account for elements such as variation in either moisture or fertility of the soil on which a crop is grown . A Latin Square design adds another dimension of control for bias and variance. Regardless of the design chosen, it is imperative to identify the proper experimental unit receiving the treatment. If animals are treated individually they may each represent a unique experimental unit. If they are exposed to the treatment as a group at the same time, for example animals housed together in a pen, such that they do not represent independent, random observations, the group may be the correct experimental unit to consider. There are many considerations to take into account when planning a bio-equivalence trial, or any other trial for comparing performance under different treatments. This talk will discuss some of these items that are often overlooked and will attempt to make suggestions on how they may be handled.

Key Words: Bio-equivalence, Power of test, Sample size

602 The power of tests for feed experiments with poultry. W. B. Roush*[1] and P. Tozer[2], [1]*USDA-ARS Mississippi State, MS*, [2]*Penn State University, University Park, PA*.

The power of tests can be used to determine the ability of an experimental design to detect treatment differences. The power of tests is rarely formally considered in poultry research. The definition of statistical power is the probability of rejecting the null hypothesis when it is, in fact, false and should be rejected. The complement of statistical power is the Type II error. That is, accepting the null hypothesis that there is no difference in treatments when, in fact, there is one. With power analysis, the sample size that is needed can be calculated to detect a given change. A priori power analysis can indicate the probability at which the sampling regime or experiment can actually detect an effect if a difference exists. Post hoc power analysis indicates either the sufficiency or the sample size needed for an experiment that has already been conducted. Because the sample size for a priori and post hoc power analyses can be larger than may be considered practical, a compromise power analysis can be conducted that calculates sample size based on a ratio of beta and alpha errors (Erdfelder, 1984). In the current study, examination was made of the power of tests for experiments published in the literature where significant and non-significant differences were reported between control birds and birds fed grains. Examination of the power of tests was conducted with G*Power, a readily available freeware program.

Key Words: Statistical power, Poultry, Experimental design