RUMINANT NUTRITION I

1527 (M241) Metagenomic analysis of the rumen microbiome of dairy cows during the transition period. D. W. Pitta*[1], S. Kumar[1], N. Indugu[1], R. Sinha[2], B. Veiccharelli[1], B. Bhukya[1], and J. Ferguson[1], [1]*University of Pennsylvania, Kennett Square,* [2]*University of Pennsylvania, Philadelphia.*

In the current study we characterized the rumen microbiome of dairy cows belonging to different lactations which were grouped as first lactation (L1; $n = 5$), second lactation (L2; $n = 2$) and third lactation (L3; $n = 2$). The rumen samples were collected using stomach tube method at four time points i.e., 3 wk before the anticipated freshening date (S1), soon after the animal freshened (S2), 4 wk (S3) and 8 wk (S4) into lactation. We pooled the genomic DNA by lactation number (3 lactation groups × 4 sampling times) to yield 12 samples. All animals received the same dry cow ration (CP-14.65%; NDF-43.66%; Starch-21.9%) before calving and the same lactating cow rations (CP-17.21%; NDF-33.14%; Starch-27.19%) post calving. The pooled genomic DNA was subjected to shotgun sequencing on Ion-torrent platform, aligned for contigs using Nextgene and uploaded to MG-Rast server for further analysis. On average 17,000 contigs per sample were obtained and subsequently used for phylogenetic and functional assignments in MG-Rast. Based on the phylogenetic data, both study group and study day tended to have an effect on the community compositions ($P < 0.12$; Permanova test) while study groups differed in their functional profiles ($P < 0.05$; Permanova test). The most abundant bacterial phyla observed were *Bacteroidetes* (60%), *Firmicutes* (20%) and *Proteobacteria* (*7%)* across all communities. As the cows transitioned into lactation, the abundance of *Bacteroidetes* decreased while that of *Firmicutes* increased. The phylum *Proteobacteria* increased in abundance with the onset of lactation and also with increased parity. The abundance of archaeal communities were found to be higher in the dry period but reduced at the onset of lactation. Both carbohydrate and protein metabolism were the most predominant functional activities with a progressive increase ($P < 0.1$) in protein utilization from L1 to L3 dairy cows. Differences also occurred in the carbohydrate and protein metabolism before and after the onset of lactation ($P < 0.05$). This study is the first report to demonstrate distinct shifts in both phylogenetic and the associated metabolic activity in both primiparous and multiparous dairy cows in their transition period.

Key Words: dairy cows, transition period, rumen microbiome, Ion-torrent, metabolic potential

1528 (M242) Peripartal supplementation of Smartamine M has positive effects on blood neutrophil activation in dairy cows. J. S. Osorio[1], P. Ji[2], J. K. Drackley[3], D. N. Luchini[4], and J. J. Loor*[5], [1]*University of Illinois, Champaign,* [2]*William H. Miner Agricultural Research Institute, Chazy, NY,* [3]*University of Illinois, Urbana,* [4]*Adisseo S.A.S., Alpharetta, GA,* [5]*University of Illinois, Urbana-Champaign, Urbana.*

An effective immune response relies on efficient activation of polymorphonuclear neutrophils (*P*MN). We evaluated mRNA expression of genes associated with metabolism of Met, glutathione, and glucose as well as inflammation, cellular receptors, and oxidative stress in PMN during the peripartal period. Twenty-eight multiparous Holstein cows in a randomized complete block design were fed a controlled-energy diet (CE, $n = 9$; 1.24 Mcal/kg DM; high-straw) during the dry period (approximately 50 d), switched to a moderate-energy (ME, $n = 9$; 1.54 Mcal/kg DM) during the last 21 d before calving, or ME plus Smartamine M (SM, $n = 10$; Adisseo France S.A.S.). After calving all cows received the same lactation diet (1.75 Mcal/kg DM). The SM (0.07% of DM) was top-dressed over the ME diet from -21 through 30 DIM. Daily dry matter intake (DMI) and milk yield were recorded. Whole blood leukocyte phagocytosis (Phagotest) was assessed and RNA from PMN was extracted from samples collected at -10, 3, and 21 DIM. Data were analyzed using the PROC MIXED of SAS. Although prepartal DMI was not affected ($P = 0.21$) by diet, postpartal DMI was lower ($P < 0.005$) in ME than CE and SM. Milk yield was also lower ($P < 0.05$) in ME than CE and SM. There was a greater ($P < 0.001$) phagocytosis in CE cows than ME and SM. Although phagocytosis decreased ($P = 0.02$) from -10 to 21 DIM regardless of treatment, there was a trend ($P = 0.10$) for an increase in phagocytosis in SM. The selectin L (*SELL*) mRNA expression was greater in SM cows at 21 DIM than CE ($P < 0.001$) and to a lesser extent ($P = 0.11$) than ME. In fact, *SELL* increased ($P < 0.001$) in SM cows from -10 to 21 DIM, while it decreased ($P = 0.006$) in CE and was unchanged ($P = 0.87$) in ME. The diet×time effect ($P = 0.005$) for superoxide dismutase 2 (*SOD2*) expression was associated with greater ($P < 0.06$) expression at 21 DIM in SM than CE and ME cows. This was reflected in a linear decrease of *SOD2* expression in CE ($P < 0.001$) and ME ($P = 0.001$), while it remained unchanged in SM ($P = 0.65$). The lower performance in cows fed ME might be related to impaired neutrophil activation, which appears to have been corrected by SM supplementation.

Key Words: immune function, transition cows, methionine

1529 (M243) Effect of a limited supply of phenylalanine, threonine, and tryptophan on mammary metabolism of dairy cows. I. H. Iroshan[1], H. Lapierre[*2], and L. Doepel[1], [1]*University of Calgary, AB, Canada,* [2]*Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada.*

Mammary metabolism is altered by deletion of essential AA (EAA) from an abomasal infusion of a total AA mixture. The objective of this study was to examine the effect of a limited supply of Phe, Thr and Trp on mammary uptake of AA and energy substrates. Five Holstein cows (63 ± 1.6 d in milk) in second lactation were used in a 5 × 5 Latin square with 10-d periods. The diet supplied 100% of net energy and 70% of metabolizable protein requirements based on NRC recommendations. Treatments were abomasal infusions of water (CTL), all AA with casein profile (TAA), TAA without Phe (No-Phe), TAA without Thr (No-Thr), and TAA without Trp (No-Trp). Mammary AA and energy substrate uptake was determined from arterio-venous differences (AV-diff) of 6 blood samples collected every 2 h on d 10, with mammary plasma flow (MPF) estimated using the Fick principle (*P*he+Tyr). Treatment differences were determined using contrasts, comparing each treatment to TAA. Arterial concentrations of Phe, Thr, and Trp decreased ($P < 0.01$) with their respective deletions. The mammary gland responded to a deficiency of Phe and Thr by reducing milk protein secretion through different mechanisms. With No-Phe, Phe uptake decreased mainly through a reduction ($P < 0.01$) of AV-diff as MPF only numerically increased. When Thr was deficient, MPF increased by 32%, and despite a large decreased ($P < 0.01$) AV-diff, Thr uptake only numerically (13%) decreased. Mammary uptakes of acetate, β-hydroxybutyrate, glucose and lactate were not affected by treatments. A limited supply of Trp had minimal impacts on mammary metabolism.

Key Words: amino acids, mammary metabolism, dairy

1530 (M244) Effects of supplementing rumen-protected met and lys on diets containing soybean meal or canola meal in lactating dairy cows. G. A. Broderick[*1], and A. Faciola[3], [1]*U.S. Dairy Forage Research Center, Madison, WI,* [2]*University of Wisconsin–Madison, Madison,* [3]*University of Nevada, Reno.*

Previously, replacing solvent soybean meal (SBM) with equal CP from canola meal (CM) was found to increase milk yield in lactating dairy cows by about 1 kg/d. We tested whether supplementing rumen-protected Met and Lys (RPML) would improve milk and protein yield in cows fed either CM or SBM. Sixteen lactating Holstein cows were blocked by DIM and parity into 4 squares of 4 cows each in a replicated 4 × 4 Latin square. There was a 2 × 2 arrangement of treatments: equal CP supplemented as either SBM or CM, with or without added RPML to provide 10 g absorbed Met/d (Mepron) plus 22 g absorbed Lys/d (AminoShureL). Cows within squares were randomly assigned to treatment sequences and fed experimental diets for 3-wk periods before switching diets. All diets contained (DM basis) 41% alfalfa silage, 25% corn silage, 2.3% mineral-vitamin premix, 1.4% ground shelled corn and 17% CP. Soybean meal diets contained 22% high moisture corn, 8.7% SBM and 28% NDF; CM diets contained 19% high moisture corn, 11.7% CM and 30% NDF. Data from the last week of each period were analyzed using the PROC MIXEDs of SAS; LS-means are reported in the table. Replacing SBM with CM increased DMI ($P = 0.04$) and tended to increase yields of energy-corrected milk and fat ($P \leq 0.09$), but there were no other affects on production ($P \geq 0.15$). Supplementing with RPML did not influence intake or yield ($P \geq 0.15$) and no significant of protein x RPML interactions were detected ($P \geq 0.15$). These results tended to support previous findings of improved milk yield on CM versus SBM. However, under the conditions of this trial, there were no effects of supplementing with rumen-protected Met plus Lys on either protein source.

Table 1529.

	Treatment						P-value contrast		
	CTL	No-Phe	No-Thr	No-Trp	TAA	SEM	CTL vs. TAA	No-Phe vs. TAA	No-Thr vs. TAA
Milk true protein yield, g/d	715	701	738	840	844	51.0	0.03	0.02	0.05
MPF, L/h	497	601	775	603	524	52.6	0.68	0.24	0.01
Mammary uptake, mmol/h									
Phe	10.1	9.0	10.9	11.9	11.8	0.85	0.04	0.01	0.22
Thr	12.1	12.6	12.6	13.6	14.2	1.06	0.10	0.20	0.18
Trp	2.9	3.0	3.1	2.9	3.1	0.39	0.64	0.81	0.92
Group 1 AA-N	48.5	49.0	51.9	55.9	56.8	3.77	0.04	0.06	0.17
Group 2 AA-N	101.7	126.8	141.8	140.9	130.1	8.85	0.02	0.76	0.26
Mammary uptake:milk output									
Group 1 AA-N	1.05	1.08	1.09	1.03	1.04	0.03	0.85	0.35	0.30
Group 2 AA-N	1.13	1.44	1.55	1.33	1.22	0.08	0.41	0.04	0.01
Non-EAA-N	0.78	0.67	0.62	0.65	0.69	0.05	0.14	0.69	0.21

Key Words: soybean meal, canola meal, rumen-protected AA

Table 1530.

Protein RPML	SSBM -	SSBM +	CM -	CM +	Contrasts		
					Protein	RPML	P x R
Trait							
DMI, kg/d	27.1	27.2	27.8	27.5	0.04	0.66	0.36
Milk, kg/d	38.4	38.1	39.1	38.5	0.18	0.27	0.71
Milk/DMI	1.42	1.40	1.41	1.40	0.79	0.38	0.81
ECM, kg/d	39.3	38.7	40.3	39.6	0.09	0.23	0.88
ECM/DMI	1.45	1.42	1.45	1.44	0.54	0.26	0.59
Fat, kg/d	1.62	1.57	1.67	1.63	0.06	0.14	0.90
Prot, kg/d	1.27	1.27	1.30	1.29	0.14	0.65	0.51
MUN, mg/dl	15.2	15.0	15.0	15.0	0.72	0.60	0.73

1531 (M245) Determination of the comparative bioavailability of lysine in two rumen-protected lysine products using the in vivo plasma lysine response method. H. A. Tucker*[1], M. Miura[2], I. Shinzato[3], C. S. Ballard[1], and H. M. Dann[1], *[1]William H. Miner Agricultural Research Institute, Chazy, NY, [2]Ajinomoto Co., Inc., Kawasaki, Japan, [3]Ajinomoto Heartland Inc., Chicago, IL.*

The objective of this study was to use the commercially available rumen-protected lysine (RPL) AjiPro-L (AJI; Ajinomoto Heartland, Inc.) to estimate relative bioavailability of a second generation RPL product (A2G; Ajinomoto Heartland, Inc.). Ten multiparous lactating Holstein cows (109 ± 8 d in milk (DIM)) housed in a tie-stall facility were used in a replicated 5 × 5 Latin square design with 7-d periods. Cows, blocked by DIM and milk production, were assigned to treatment sequence. A common basal diet formulated to meet lysine (Lys) requirement, prepared once daily, was fed proportionately at three time points (33.4% at 0500 h, 33.3% at 1300 h, and 33.3% at 2100 h). Treatments included 0 g/d Lys, 75 g/d AJI, 75 g/d A2G, 150 g/d AJI, or 150 g/d A2G and were administered 3x/d 1 h before each feeding time on d 2 through 7 of each period in amounts proportional to feed offered to simulate inclusion in the diet. Blood samples were obtained from each cow on d 6 and 7 of each period from the tail vein at 2-h intervals starting at 0600 h resulting in four samples/cow/d. Resultant plasma was pooled by day and analyzed for amino acid (AA) concentrations. Data were reduced to a period mean and analyzed using the PROC MIXED (SAS, v. 9.2). The REG procedure was used to generate linear regression models for each RPL product using Lys (μmol) and Lys (% total AA (μmol basis)) to determine the slope of plasma Lys in response to treatment. Using the calculated slope for each product, relative estimated bioavailability of A2G was determined using the slope-ratio assay technique. Dry matter intake and milk yield did not differ ($P > 0.10$) among treatments. Plasma Lys was greater ($P < 0.05$) for 150 g/d AJI (93.8 ± 2.9 μmol) and 150 g/d A2G (95.0 ± 2.8 μmol) when compared to 0 g/d Lys (83.6 ± 2.9 μmol). The slope for A2G treatment was numerically greater (0.007; $r^2 = 0.91$) when compared to the slope for AJI treatment (0.005; $r^2 = 0.99$) when expressing the concentration of plasma Lys relative to that of total AA. This resulted in the calculated bioavailability of A2G being 132.1% of the bioavailability of AJI. Both first and second generation AjiPro-L products increased plasma LYS in lactating dairy cows with some comparative advantage for the second generation product.

Key Words: bioavailability, rumen-protected lysine, dairy cow

1532 (M246) Impacts of feeding ruminally protected phenylalanine and/or methionine to early lactation cows fed diets containing high levels of canola meal. N. Swanepoel*[1,2], P. H. Robinson[1], and L. J. Erasmus[2], *[1]University of California–Davis, Davis, [2]University of Pretoria, Pretoria, South Africa*.

The objective of this study was to determine if either Met or Phe was limiting performance of dairy cows fed a ration containing 200 g/kg of diet DM as canola meal (CM). The design used four pens of 320 early lactation (DIM < 125) cows/pen in a 4x4 Latin square with 28 d periods. Treatments were designed to deliver 8.0 and 7.5 g/cow/d of intestinally absorbable Met and Phe, respectively with treatment pens fed ruminally protected (RP) Phe (RPP) and RP Met (RPM), separately or in combination, mixed into the same control TMR based on alfalfa hay, winter wheat and corn silage, almond hulls, corn grain, fuzzy and cracked pima cottonseed and mineral premix. There were no difference in the chemical profiles of the TMR fed to the four treatments with CP, NDF, Fat and Starch amounting to 170, 310, 53, and 193 g/kg DM in the base TMR. There were no changes in plasma AA levels except plasma Met, which increased with both Met treatments, and plasma Trp that decreased with both Phe treatments. DM intake was not affected (avg: 27.6 ± 0.40 kg/d) by feeding either RP AA or the combination. Compared to control, supplemental Met increased milk protein (30.71 vs. 30.18 g/kg; $P < 0.01$) and fat (34.74 vs. 34.16 g/kg; $P = 0.01$) content, while decreasing milk lactose (47.47 vs. 47.80 g/kg; $P < 0.01$) content, thereby shifting milk energy amongst milk components without affecting milk energy output. Even though Phe alone had no effect at all on animal performance, adding it in combination with Met diverted energy away from milk components towards body condition score (BCS) gain, which increased (0.08 vs. 0.04 BCS unit change/28d; $P < 0.01$). Even though the supplemented Phe did not increase plasma Phe levels, or animal performance, it was clearly delivered and biologically active based on the finding that it changed the way that Met was utilized. While results suggest that neither Met nor Phe was a limiting AA in this study, results do suggest that both were bioactive. It may be time to reconsider the limiting AA

concept in lactating dairy cows in favor of accepting that AA may be bioactive to the extent of changing animal performance, even when they are not limiting.

Key Words: urine spot samples, amino acids, allantoin

1533 (M247) Ruminal degradation and intestinal digestibility of crude protein and amino acids and correction for microbial contamination in rumen-undegradable protein.

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Two Holstein cows fitted with ruminal and proximal duodenal cannulas were used to determine crude protein (CP) and AA ruminal degradation using an in situ incubation of 16 h and intestinal digestibility using the mobile bag technique (pore size 50 μm). Bacterial contamination of the rumen-undegradable protein (RUP) was corrected using purines or DNA as bacterial markers. The feedstuffs evaluated were: three sources of blood meal (BM1, BM2, and BM3), canola meal (CM), low-fat distillers dried grains with solubles (LFDG), soybean meal (SBM), and expeller soybean meal (ESBM). Data were analyzed as a randomized complete block. Ruminal degradation of CP varied ($P < 0.001$) across feedstuffs, 85.3, 29.8, 40.7, 75.7, 76.9, 68.8, and 37.0 ± 3.93% for BM1, BM2, BM3, CM, LFDG, SBM, and ESBM, respectively. Ruminal degradation of both total essential AA and nonessential AA followed a similar pattern to that of CP. Based on the ratios of AA concentration in the RUP to AA concentration in the original feed, ruminal incubation decreased (ratio < 1; $P < 0.001$) the concentrations of His, Lys, and Trp and increased (ratio > 1; $P > 0.001$) the concentrations of Ile and Met across feedstuffs. Estimations of BCP contamination using purines were 0.75 ± 0.86, 0.65 ± 0.88, 0.55 ± 0.91, 2.50 ± 0.88, 6.45 ± 0.91, 2.61 ± 0.88, 10.8 ± 0.91% CP and using DNA were 0.68 ± 0.86, 0.18 ± 0.88, 0.63 ± 0.91, 4.52 ± 0.88, 2.58 ± 0.91, 1.36 ± 0.88, and 2.49 ± 0.91% CP for BM1, BM2, BM3, CM, LFDG, SBM, and ESBM, respectively. Intestinal digestibility of RUP could not be estimated for BM1, BM3, and SBM due to insufficient recovery of residue. For the remaining feedstuffs, intestinal digestibility of RUP was highest ($P < 0.001$) for ESBM, followed by BM2 and LFDG, and lowest for CM, 98.8, 87.9, 89.7, 72.4 ± 1.40%, respectively. Intestinal absorbable dietary protein was higher ($P < 0.001$) for BM2 compared to CM and LFDG, 61.7, 17.9, and 20.7 ± 2.73% CP, respectively. Ruminal degradation and intestinal digestibility of AA determine the supply of intestinal absorbable AA across feedstuffs. These factors are not constant across AA within feedstuffs and nutrition models need to account for them to increase the accuracy to predict the AA supply to the animal.

Key Words: rumen degradation, intestinal digestibility, amino acids, bacterial CP contamination

1534 (M248) Validation of the bioavailability of the second generation AjiPro-L using the in vivo plasma lysine response method.

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Six lactating multiparous Holstein (DIM = 64 to 314) equipped with ruminal cannulas were used in a 6 × 6 Latin square study with 7-d periods. The treatments were: 1) 0 g/d Lys, 2) 60 g/d of infused Lys, 3) 30 g/d of fed Lys from AjiPro-L, 4) 60 g/d fed Lys from AjiPro-L, 5) 30 g/d fed Lys from AjiPro-L 2G, and 6) 60 g/d fed Lys from AjiPro-L 2G. The infusion treatments consisted of Lys-HCl and were infused continuously into the abomasum via the ruminal cannulas. To ensure complete consumption, the AjiPro-L and AjiPro-L 2G were mixed with 1 kg of TMR and placed in tubs in front of the cows 30 min before each of the 3 daily feedings. Blood samples were obtained from each cow on the last 3 d of each period every 2 h, four times daily, from the tail vein, centrifuged, deproteinized, and composited into one daily sample/cow. Deproteinized plasma was analyzed for AA. Data for plasma AA concentrations (μmol basis) were analyzed using the PROC MIXED and PROC REG procedures of SAS. The bioavailability of AjiPro-L, calculated by comparing the slopes of the infused and fed AjiPro-L (Lys as % of total AA), was lower than previous evaluations using the same methodology. The infusion slope observed herein, obtained from two doses (0 and 60 g/d), was larger than those obtained previously, which were obtained using three doses (0, 30, and 60 g/d); this may explain the discrepancies among studies. To increase precision, it is recommended that at least 1 additional dose of infused Lys between 0 and 60 g/d should be used. It is important to note that the slope for the AjiPro-L 2G (i.e., 0.01011; $P < 0.01$) was greater than the slope for the AjiPro-L (i.e., 0.00682; $P < 0.01$) resulting in a 48% improvement in bioavailability of Lys from the AjiPro-L 2G based on the ratio of the 2 slopes. It can be concluded that the bioavailability of Lys from AjiPro-L 2G was better than that from AjiPro-L. Further research is needed to test these 2 RP-Lys products.

Key Words: AjiPro-L, bioavailability, lysine

1535 (M249) Comparison of duodenal nitrogen and amino acid flows in dairy cows fed a corn straw or mixed forage diet. C. Qin[1,2], P. Sun[1], D. P. Bu[*1], J. Q. Wang[1], P. Zhang[2], and P. An[1], *[1]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [2]Hunan Provincial Key Laboratory for Genetic Improvement of Domestic Animal, College of Animal Science and Technology, Hunan Agricultural University, Changsha, China*.

Knowledge to duodenal nitrogen and amino acid flows may provide guidance to nutritionists with dairy rations. This study was conducted to evaluate the effects of dietary factors that alter ruminal fermentability on duodenal flows of nitrogen and amino acids (AAs). Twenty-four primiparous, lactating, ruminally and duodenally fistulated Holstein cows were used in this study. Cows were randomly assigned to high forage diet (HF, forage:concentrate = 60:40) with Chinese wildrye, alfalfa hay and corn silage as the forage source or low forage diet (LF, forage:concentrate = 40:60) with corn straw as the forage source. This study lasted for 11 wk with 2-wk of preliminary period and 9-wk of trial period. Co-EDTA, Cr_2O_3 and $YbCl_3 \cdot 6H_2O$ were used as indicators in the last 3 wk. Samples were collected in the last three trial days and all samples were kept at -20°C for further analysis. Data were analyzed using the PROC MIXED (SAS 9.1) and expressed as gram per day (g/d). The HF diet had positive effect on flows of duodenal total nitrogen (369.75 and 539.39), Arg (90.53 and 136.20), His (37.65 and 55.97), Ile (100.24 and 150.44), Leu (157.25 and 234.10), Lys (132.31 and 202.80), Met (26.63 and 40.31), Phe (92.81 and 145.96), Thr (79.00 and 123.04), Val (110.39 and 168.14), Asp (183.23 and 277.74), Ser (59.45 and 91.31), Glu (253.40 and 372.30), Ala (118.30 and 178.80), Cys (16.83 and 23.67), Tyr (55.99 and 84.45), Pro (82.58 and 120.45), essential AA (826.82 and 1256.97), non-essential AA (903.03 and 1339.11) and total AA (1729.85 and 2596.08) ($P < 0.05$). Duodenal Gly flow tended to be higher in cows fed with HF diet (133.26 and 190.40, $P = 0.07$). Flows of duodenal bacterial nitrogen (215.93 and 263.27), endogenous nitrogen (37.82 and 37.95) and non-degradable nitrogen (136.35 and 183.61) were not affected by dietary treatments ($P > 0.05$). In conclusion, dietary systems played a role in duodenal nitrogen nutrition flows, and duodenal total nitrogen and amino acid flows were depressed when cows fed a low forage diet.

Key Words: forage pattern, dairy cow, duodenal nutrition flow, nitrogen nutrition

1536 (M250) Comparison of mammary amino acid utilization in dairy cows fed a corn straw or mixed forage diet. C. Qin[1,2], P. Sun[2], D. P. Bu[2], J. Q. Wang[*1,2], P. Zhang[3], and P. An[2], *[1]Heilongjiang Bayi Agricultural University, Daqing, China, [2]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [3]Hunan Provincial Key Laboratory for Genetic Improvement of Domestic Animal, College of Animal Science and Technology, Hunan Agricultural University, Changsha, China.*

It is reported that changes in mammary amino acid (AA) utilization associate with dietary systems. In this study, we investigated AA transformation efficiency (AATF) from mammary gland to milk production in dairy cows fed different diets. Twenty-four first lactating Holstein cows were used in this study. Cows were randomly assigned to high forage diet (HF, forage:concentrate = 60:40) with Chinese wildrye, alfalfa hay and corn silage as the forage source or low forage diet (LF, forage:concentrate = 40:60) with corn straw as the forage source. This study lasted for 11 wk with 2 wk of preliminary period and 9-wk of trial period. Milk samples, blood in perineal artery and jugular vein were collected on the last morning of the trial, respectively. All samples were kept at -20°C for further analysis. To estimate AATF data were fitted to the model AATF = A/(B*C), where: A (g/d) was milk AA yield; B (g/L) was the concentration difference of plasma AA in perineal artery and jugular vein; C (L/d) was blood flow volume in mammary gland. Data were analyzed by PROC MIXED (SAS 9.1). The results showed that transformation efficiency of Phe increased in cows fed HF diet (0.72 vs. 0.88, $P < 0.01$). We observed that transformation efficiency of Thr (0.77 vs. 0.61), Asp (16.84 vs. 7.62) and Ser (2.01 vs. 1.26) was lower in HF group ($P < 0.05$), and HF diet tended to have a negative effect on non-essential AA transformation efficiency (1.95 vs. 1.45, $P = 0.08$). However, transformation efficiency of Arg (0.35 vs. 0.34), His (1.04 vs. 1.07), Ile (0.57 vs. 0.61), Leu (0.68 vs. 0.72), Lys (0.80 vs. 0.73), Met (0.74 vs. 0.60), Val (0.64 vs. 0.67), Glu (1.81 vs. 2.06), Gly (1.06 vs. 0.99), Ala (0.71 vs. 0.70), Cys (1.09 vs. 2.64), Tyr (0.80 vs. 0.84), Pro (3.75 vs. 3.32), essential AA (0.65 vs. 0.65) and total AA (1.01 vs. 0.97) were not affected by dietary treatment ($P > 0.05$). These results indicated that feeding a high forage diet to cows depressed mammary utilization of some amino acids but improved phenylalanine conversion efficiency.

Key Words: diet system, mammary gland, amino acid utilization

1537 (M251) Plasma L-methionine and supplemental L-methionine precursor responses to rumen administration of a rumen protected DL-methionine source or different levels of 2-hydroxy-4-methylthio-butanoic acid. *G*. I. Zanton*, S. E. Bettis, and M. Vazquez-Anon, *Novus International, Inc., St. Charles, MO.*

The L-enantiomer of methionine (Met) is the form that can be used for biological functions. Supplemental precursors of L-Met such as D-Met or 2-hydroxy-4-methylthio-butanoic acid (HMTBa) must be converted to L-Met to be incorporated into protein. The objective of this study was to evaluate the plasma response of L-Met and supplemental L-Met precursors to a rumen pulse dose of protected DL-Met (Smartamine M, Adisseo, France; RPM) or different levels of HMTBa. Six rumen cannulated Holstein steers (initial BW = 250 ± 6 kg SD) were fed a common basal diet and pulse dosed with different treatments according to a partially replicated Latin square design. Treatments administered to the rumen were 80 (H80), 120 (H120), or 160 (H160) mg HMTBa/kg BW (Provided as MFP feed supplement, Novus International, St. Charles, MO) or RPM at 80 mg DL-Met/kg BW (RPM80); where, based on previous research, H160 and RPM80 were hypothesized to provide similar levels of absorbed Met activity (64 mg/kg BW). Ruminal pulse dose coincided with morning feeding and occurred at t = 0 with 11 plasma samples taken from the coccygeal vein over the ensuing 48 h and analyzed for HMTBa, D-Met, and L-Met. Statistical contrasts were linear and quadratic effects of level of HMTBa and H160 vs. RPM80 with significance declared at $P < 0.05$. Baseline L-Met was not different between treatments averaging 2.75 mg/L; L-Met precursors were not detected in baseline samples. Plasma profiles of L-Met and supplemental L-Met precursors differed between levels and sources ($P < 0.01$). The change in L-Met from baseline area under the response curve through 48 h (AUC) was linearly increased ($P < 0.02$) as HMTBa increased; L-Met AUC for H160 did not differ from RPM80 (128 vs. 147 ± 17 mg·h/L, respectively; $P > 0.40$). Likewise, supplemental L-Met precursor AUC linearly increased as HMTBa level increased; HMTBa AUC for H160 did not differ from RPM80 D-Met AUC (140 vs. 117 ± 11 mg·h/L, respectively; $P > 0.14$). When not separated on a chiral column, D- and L-Met are combined during plasma Met analysis; when analyzed values for D-Met or HMTBa were added to analyzed values for L-Met, there was no difference between AUC for H160 and RPM80 (268 mg·h HMTBa + L-Met/L vs. 264 mg·h D- + L-Met/L ± 24, respectively; $P > 0.90$). It is concluded that supplying a pulse dose of 64 mg methionine activity/kg BW as RPM or HMTBa resulted in plasma L-Met concentrations that were not different.

Key Words: methionine, dairy, bioavailability

1538 (M252) Effects of the ideal profiles of lysine, methionine, threonine, phenylalanine, histidine, and valine on milk protein synthesis gene network expression in bovine mammary epithelial cells. S. Li[1,2], W. Zhao[2,3], A. Hosseini[4], J. X. Liu[1], and J. J. Loor[*2], *[1]Zhejiang University, Hangzhou, China, [2]University of Illinois, Urbana, [3]Northwest A & F University, Yangling, China, [4]University of Bonn, Germany.*

Amino acids (AA) are essential precursors for milk protein synthesis in mammals. In recent years it has become evident that the AA-mediated protein synthesis response within mammary cells is partly regulated through the mTOR pathway. Thus, AA not only are building blocks of proteins but also are one of the key molecules that serve as upstream components of the signaling pathways that regulate protein synthesis. Although the effects of AA on signaling through mTOR in mammary cells have been explored, little is known about the transcriptional response, particularly regarding the 6 essential AA [lysine (Lys), methionine (Met), threonine (Thr), phenylalanine (Phe), histidine (His), and valine (Val)] for which ideal recommendations have been proposed. The specific objective of this study was to investigate how changing the ratio of Lys to Thr, Lys to His, and Lys to Val affected the expression of genes associated with pathways of insulin, mTOR, and Jak2-Stat5 signaling and also glucose and AA transport in MacT cells. Target genes plus three internal controls were measured using qPCR. Triplicate cultures with the optimal AA ratio (OPAA; Lys:Met 2.9:1; Thr:Phe, 1.05:1; Lys:Thr, 1.8:1; Lys:His, 2.38:1; Lys:Val, 1.23:1) plus the mTOR inhibitor rapamycin (OPAARMC, control) or OPAA, 2.1:1 Lys:Thr (LT2.1), 1.3:1 Lys:Thr (LT1.3), 3.05:1 Lys:His (LH3.0), and 1.62:1 Lys:Val (LV1.6) were incubated for 12 h. Compared with OPAARMC the OPAA treatment upregulated SLC1A5, SLC7A5, and RPS6KB1, and downregulated expression of IRS1, AKT3, TSC2, and EEF1A1. Greater expression of SLC1A5, SLC7A5, SLC2A1, SLC2A8, STAT5B, and RPS6KB1 and lower expression of TSC2 and EEF1A1 were observed in response to LT2.1, LT1.3 and LH3.0 compared with OPAARMC. Treatment with LV1.6 as compared with LT2.1, LT1.3 and LH3.0 had similar effects on expression of SLC1A5, SLC7A5, SLC2A1, SLC2A8, STAT5B, and RPS6KB1. In addition, treatment with LV1.6, LH3.0, and LT2.1 compared with OPAA and control led to greatest upregulation of mTOR. However, only LV1.6 up-regulated TSC1 and TSC2 and downregulated EIF4EBP1 relative to OPAA and control. Overall, our study revealed unique effects of essential AA ratios, and particularly Lys:Val, on the molecular phenotype associated with milk protein synthesis regulation in mammary cells.

Key Words: mTOR, nutrigenomics, milk protein synthesis

1539 (M253) Changes in plasma methionine concentrations after administration of two different doses of rumen protected methionine.

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Feeding rumen-protected limiting amino-acids, such as methionine (MET), to dairy cows may allow feeding of diets with lower amounts of crude protein while increasing milk protein and feed efficiency. Information on the changes of circulating MET concentrations after feeding may provide valuable information on both its usage and its metabolism, which could then be used by field nutritionists. The objective of the present experiment was to determine changes in plasma MET concentrations after administration of a single bolus of rumen-protected methionine (RPM). Non-lactating, non-pregnant dairy cows (n = 16) weighing 694 ± 16 kg were randomly assigned to three treatments: 1) untreated control (n = 4); 2) bolus containing 10 g of RPM (Smartamine; 6 g of metabolizable MET; n = 6); and 3) bolus containing 20 g of RPM (Smartamine; 12 g of metabolizable MET; n = 6). Blood samples were collected at 12h before treatment, immediately before treatment, and at 6, 12, 18, 24, 36, and 48h after treatment. Plasma was assayed for free amino acid by gas chromatography using a commercial kit (EZ:faast-GC-FID Physiological, Phenomenex). Data were analyzed by repeated measures using the PROC MIXED of SAS. Plasma MET concentrations tended to differ among treatments (P = 0.08) and were greater for cows receiving the 20 g bolus, intermediate for cows receiving the 10 g bolus, and least for control cows (peak average 57.5 ± 0.8μM, 26.9 ± 0.2μM, and 20.3 ± 0.2μM, respectively). Before treatment, all cows had low MET concentrations (21.4 ± 0.5μM), and MET concentrations remained low throughout the experimental period in controls. At 12 and 18h, MET concentrations increased (P = 0.09) by 30% in cows receiving the 10 g bolus (26.5 ± 0.2μM) compared to control cows (20.3 ± 0.1μM); however, cows receiving the 20 g bolus increased more than 100% (50.4 ± 4.1μM) and were greater than either controls (P < 0.01) or cows treated with the 10 g bolus (P < 0.01). By 24 h after treatment, MET concentrations differed among treatments (P < 0.001) and were least for controls (22.7 ± 0.1μM), intermediate for cows receiving the 10 g bolus (23.7 ± 0.1μM), and greater for cows receiving the 20 g bolus (29.6 ± 0.1μM). Methionine concentrations did not differ among treatments (P = 0.85) at 36 and 48 h. Lysine concentrations did not differ among treatments (P = 0.52) and were 143.3 ± 5.2μM, 133.3 ± 5.4μM, and 139.6 ± 6.8μM for controls, cows receiving 10 g of RPM, and cows receiving 20 g of RPM, respectively. In conclusion, plasma MET concentrations were affected by treatment dose and time after treatment. Time after treatment should be considered when evaluating effectiveness of MET supplementation. *Supported by Hatch project WIS01240 and Adisseo USA, Inc.*

Key Words: methionine, dairy cow, amino acids

1540 (M254) A three-step in vitro procedure for evaluating rumen-protected lysine products.

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The three-step in vitro procedure is used for estimating intestinal digestibility of the RUP fraction of feedstuffs. However, rumen protected amino acid products have been evaluated in various ways for estimates of bioavailability. The objective of this study was to propose a three-step in vitro procedure for rumen-protected Lysine products (RPL), which is composed of buffer solutions with enzymes and can be developed as a standardized method to evaluate RPLs. Three grams of six different RPLs were weighed into nylon bag (5 × 7 cm, pore size 53 ± 10 μm). Bags were incubated using a dissolution apparatus for drug evaluation with rotating paddles at 100 rpm at 39°C. Three individual vessels were allocated to each RPL as ruminal, abomasal and duodenal phases, respectively. Modified McDougal's buffer containing lipase (900 mL) was used to simulate ruminal conditions (pH 6.8). A hydrochloride buffer containing pepsin (900mL, pH 2.0) and a phosphate buffer containing pancreatin and gall powder (900 mL, pH ≈ 7.9) were used to simulate abomasal and intestinal conditions, respectively. After a 20-h incubation in ruminal vessels, aliquot samples of solution were taken, and bags containing each RPL were transferred from ruminal to abomasal vessels. These procedures were repeated after a 2-h incubation followed by incubation in duodenal vessels for 8 h; aliquot buffer samples were taken again. Each buffer sample was analyzed for Lys, and amount of lysine escaping dissolution was calculated by subtracting buffer lysine from original feed lysine provided to the assay. Residual Lys under ruminal conditions was compared with extent of in situ ruminal protection. Statistical differences (P < 0.05) were tested by a one-way ANOVA. In vitro ruminal protection measured by this procedure correlated (P < 0.05) with in situ ruminal protection with a correlation coefficient of > 0.9. The RPLs showed various characteristics; high/medium/low ruminal protection and high/low post-ruminal Lys release. However, when pH of the ruminal buffer was reduced, one of the RPLs showed an increase (P < 0.05) in ruminal protection using in vitro procedures (46.2 ± 9.3% at pH 6.8, 90.0 ± 4.0% at pH 6.2, n = 3). Results from this study indicate that a buffer-based three-step in vitro procedure can be a useful tool to evaluate RPLs, but further research is needed to optimize pH of ruminal conditions.

Key Words: rumen-protected lysine, in vitro procedure, rumen pH

1541 (M255) Histidine requirement of dairy cows determined by the indicator amino acid oxidation (AAO) technique. D. R. Ouellet[*1], G. E. Lobley[2], and H. Lapierre[1], *[1]Agriculture and Agri-Food Canada, Sherbrooke, QC, [2]Rowett Institute of Nutrition and Health, University of Aberdeen, UK.*

The indicator AAO technique has been used successfully to quantify AA requirements in pigs and poultry. This technique was used to evaluate His requirement in dairy cows. Six lactating dairy cows were used in a 6 × 6 Latin square design, with 7-d periods. Cows were fed a TMR balanced to provide 110% and 75% of energy and metabolizable protein (MP; 1653 g/d) requirement, respectively. All AA (813 g/d; casein profile), excluding His, were infused into the abomasum to supply 105% of MP requirement. Treatments were abomasal infusion of His at 0, 7.6, 15.2, 22.8, 30.4 and 38.0 g/d, representing 1.50, 1.83, 2.15, 2.46, 2.78, and 3.09% of MP. On d6, [1-^{13}C]leucine was infused intravenously for 5 h (4.0 mmol/h; prime dose 4.0 mmol). Six blood samples were collected every 20 min during the last 2 h of infusion and the isotopic enrichment of plasma keto-isocaproic acid and CO_2 used to estimate whole body (WB) Leu irreversible loss rate (ILR) and oxidation. On d 7, $NaH^{13}CO_2$ was infused (2 mmol/h; prime dose 2.8 mmol) intravenously, with a similar schedule as d 6, to estimate the WB ILR of CO_2. Leucine and CO2WB ILR were not affected by treatments and averaged 126.8 ± 2.15 mmol/h and 23.4 ± 0.98 mol/h, respectively. Yields of milk and milk protein, and Leu oxidation (indicator AAO) all indicated that a His supply of 1.83%MP was sufficient to meet requirement. However, the consistent decrease in plasma concentrations of carnosine (β-alanyl-His dipeptide) below 2.46%MP suggests provision of His from endogenous pools; this could temporarily mask a dietary deficiency. The indicator AAO method is sensitive and provides similar estimates of requirement to those based on milk protein yield. Nonetheless, to accurately estimate His requirements needs consideration of changes in endogenous pools of His.

Key Words: dairy cow, amino acid oxidation, histidine

1542 (M256) Estimation of histidine requirement in lactating dairy cows. H. Lapierre[*1], D. R. Ouellet[2], and G. E. Lobley[3], *[1]Agriculture and Agri-Food Canada, Sherbrooke, QC, [2]Agriculture and Agri-Food Canada, Sherbrooke, QC, [3]Rowett Institute of Nutrition and Health, University of Aberdeen, UK.*

Although in lactating dairy cows, His and Met show similar hepatic and mammary behaviour, with similar concentration in milk, requirement for His has been variously estimated as 2.4% (Doepel et al., 2004, JDS 87:1279), 2.7% (CPM-Dairy) and 3.2% (Rulquin et al., 2001, INRA ProdAnim 14:265) of metabolizable protein (MP) supply. Such variability may be

Table 1541.

	His supply (% of MP)							*P* value	
	1.50	1.83	2.15	2.46	2.78	3.09	SEM	Linear	Quad.
DMI, kg/d	19.5	20.2	20.1	20.3	20.3	20.3	0.18	0.01	0.06
Yields									
Milk, kg/d	38.6	42.1	42.0	42.5	42.8	42.4	0.66	0.002	0.02
True protein, g/d	973	1141	1152	1168	1163	1139	20.7	< 0.001	< 0.001
Leu oxidation, mmol/h	34.2	24.9	25.2	21.9	24.5	23.3	1.88	0.01	0.02
Plasma concentrations									
His, µM	18.0	24.7	46.4	63.3	61.2	68.4	3.42	< 0.001	< 0.01
Carnosine, µM	6.4	6.9	8.4	9.2	9.3	9.8	0.56	< 0.001	0.29
Anserine, µM	4.8	6.5	5.5	6.6	5.5	5.5	0.71	0.77	0.18

Table 1542.

	His supply (% of MP)					P Value	
	1.60	1.95	2.30	2.65	SEM	Linear	Quadratic
DMI, kg/d	20.1	20.1	20.7	20.7	0.26	0.08	0.92
Yields							
Milk, kg/d	32.3	34.0	36.3	36.8	0.53	< 0.001	0.32
True protein, g/d	875	1035	1057	1116	25.7	< 0.001	0.08
Plasma concentrations							
His, µM	14.5	33.4	51.9	60.1	3.18	0.001	0.12
Hemoglobin, g/100 mL	9.2	9.5	9.7	9.4	0.21	0.41	0.17
Muscle concentrations							
Carnosine, µM	8373	8478	9188	6841	647.9	0.21	0.09
Anserine, µM	1349	1306	1422	993	101.4	0.07	0.09

explained by depletion or replenishment of endogenous pools of His, including intramuscular carnosine and anserine and blood hemoglobin. To test this hypothesis, five multiparous Holstein cows (674 ± 36 kg BW, 92 ± 18 DIM) were used in a 4 × 4 Latin square plus one cow, with 14-d periods. Cows were fed a diet balanced to supply 103% of NEL requirement but only 72% of MP requirement (1610 g/d) providing 34 g/d of digestible His (NRC, 2001). Treatments were abomasal infusion of His at 0, 7.6, 15.2 or 22.8 g/d in addition to a mixture of AA (595 g/d, casein profile). His represented 1.60, 1.95, 2.30 and 2.65% of MP supply, respectively. At the end of each period, six arterial blood samples plus muscle biopsies from the semimembranous muscle were collected. Milk yield plateau was reached at a higher His supply (2.30%MP) than milk protein yield (1.95%MP). Between these supplies, however, milk protein yield could be sustained from depletion of endogenous pools. Observed reductions in muscle carnosine and anserine plus plasma hemoglobin could supply 3.2 g of His/d. Compared with other essential AA, the unique peculiarity that His has additional endogenous labile pools means that depletion and/or replenishment of these pools over short periods may bias estimate of true requirement.

Key Words: histidine, carnosine, dairy cow

1543 (M257) Effects of different protein sources on milk performance and amino acid profile in early lactating dairy cows. X. Q. Zhou[*1,2], D. P. Bu[1], Y. D. Zhang[1], M. Zhao[1], P. Sun[1], and J. Q. Wang[1], *[1]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [2]Northeast Agricultural University, Harbin, China.*

Protein content of feed plays an important role in dairy amino acid profile of bovine milk protein. This study was aimed to investigate different protein sources on milk production performance and milk amino acid profile. Thirty-two Chinese Hostein dairy cows were blocked based on DIM (60 ± 25 d) and milk yield (31.0 ± 3.17kg/d) and randomly divided into group soybean (diet protein, soybean meal 11.29%, extruded soybean 2.06%, whole cottonseed 10.44%, rapeseed meal 4.19%, beet pulpand 4.16% and cottonseed meal 2.13%) and group non-soybean (whole cottonseed 10.44%, rapeseed meal 9.63%, cottonseed meal 6.71% and beet pulp 7.49%). Two diets contained similar forage with the same concentrate-to-forage ratio of 65:35 (DM basis).Experiment lasted for 12 wk with first 2 wk as adaption period. Milk samples were collected weekly and analyzed for milk composition and amino acid profile. Data were analyzed as repeated measurements using PROC MIXED of SAS. Milk yield, milk protein content, milk fat content, milk protein yield and milk fat yield showed no difference between two groups. Compared with group soybean, Cows in group no-soybean increased DMI (20.31vs 17.43kg/d, $P < 0.01$) and milk Pro content (8.48 vs. 8.37 g/100 g AA, $P = 0.04$) but decreased milk Phe content (5.54 vs. 5.60 g/100 g AA, $P = 0.02$) and BCAA (23.49 vs. 23.68 g/100 g AA, $P = 0.08$), especially Leu content (11.69 vs. 11.88 g/100 g AA, $P < 0.01$) in milk protein. There were no difference on content of EAA, NEAA between 2 groups. Results suggest that soybean meal can be partly replaced by miscellaneous meal (rapeseed meal, cottonseed meal and beet pulp) in diets for lactating dairy cows.

Key Words: protein source, milk amino acid profile, dairy cow

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1544 (M258) Lipogenic gene network expression in bovine mammary epithelial cells in response to the "ideal" profile of Lys, Met, Thr, Phe, His, and Val. S. Li[1,2], W. Zhao[1,3], A. Hosseini[4], J. X. Liu[2], and J. J. Loor[*1], *[1]University of Illinois, Urbana, [2]Zhejiang University, Hangzhou, China, [3]Northwest A & F University, Yangling, China, [4]University of Bonn, Germany.*

Amino acids (AA) not only are building blocks of proteins but also are key factors regulating protein synthesis. In regards to milk protein synthesis, the 6 essential AA (EAA) for which ideal recommendations have been proposed are Lys, Met, Thr, Phe, His, and Val. We hypothesized that the essential AA profile could affect the mRNA expression of genes regulating lipogenic gene networks in bovine MAC-T cells. The specific objective of this study was to study how changing the ratio of Lys to Thr, Lys to His, and Lys to Val affects the expression of lipogenic target genes. Triplicate cultures with the optimal AA ratio (OPAA; Lys:Met 2.9:1; Thr:Phe, 1.05:1; Lys:Thr, 1.8:1; Lys:His, 2.38:1; Lys:Val, 1.23:1) plus rapamycin (OPAARMC, control), OPAA, 2.1:1 Lys:Thr (LT2.1), 1.3:1 Lys:Thr (LT1.3), 3.05:1 Lys:His (LH3.0), and 1.62:1 Lys:Val (LV1.6) were incubated for 12 h. The expression of lipogenic gene networks was evaluated via quantitative PCR of 15 genes plus three internal control genes measured using qPCR. Data were log-transformed and statistically analyzed using the GLM of SAS with treatment as a fixed effect and replicate as random effect. The multiple comparisons were corrected using Tukey's and significance set a $P < 0.05$. Responses to LT2.1, LT1.3, LH3.0, and LV1.6 relative to the OPAARMC included greater expression of ACSS2, FABP3, ACACA, FASN, SCD, LPIN1, INSIG1, SREBF1, PPARD, and NR1H3. Furthermore, LV1.6 increased expression of ACSL1, DGAT1, and RXRA and reduced PPARG expression. Although no effect of OPAA on expression of PPARG was observed, OPAA increased expression of ACSS2, FABP3, ACACA, FASN, SCD, LPIN1, INSIG1, and SREBF1 compared with OPAARMC. Gene network analysis using Ingenuity Pathway Analysis revealed a potentially important role of EAA ratios in the coordination of milk fat synthesis via PPARG and SREBF1. The upregulation of lipogenic gene

networks observed underscore a role of EAA in the regulation of milk fat synthesis during lactation.

Key Words: nutrigenomics, milk fat synthesis, mTOR

1545 (M259) Rumen-protected methionine and choline supplementation during the transition period enhance the proinflammatory cytokine response of whole blood. M. Vailati Riboni[*1,2], Z. Zhou[2], D. N. Luchini[3], A. Minuti[1], E. Trevisi[1], and J. J. Loor[2], *[1]Università Cattolica del Sacro Cuore, Piacenza, Italy, [2]University of Illinois, Urbana, [3]Adisseo S.A.S., Alpharetta, GA.*

The immune system of dairy cows declines in responsiveness during the transition period. In spite of this, there are several factors that can stimulate immune cells and induce the production of proinflammatory cytokines (PIC). The objective of this study was to investigate the effect of supplementing rumen-protected methionine or choline on the production of the proinflammatory cytokine IL1-β by whole blood challenged with *E. Coli* lipopolysacharide (LPS). Twenty-four multiparous Holstein cows were dried off at −50 d from parturition (DFP) and allocated to 1 of 3 treatment groups (n = 8/group) starting on -24 DFP; control (CON; fed a basal diet with a 3.4:1 Lys:Met), methionine (MET; basal diet plus Smartamine M with a 2.9:1 Lys:Met), and choline (CHO; basal diet plus ReaShure, 60 g/d). Blood samples for LPS challenge were collected on -15, −7, 2, 7, and 20 DFP into evacuated tubes containing lithium-heparin and kept at 38°C. An ex vivo whole blood (1 mL) stimulation assay was performed within 30 min using LPS at three different doses, 0 (negative control, CTR), 0.01, and 5 μg/mL blood. Samples were incubated for 3.5 h. At the end of incubation the plasma was collected after centrifugation and used to analyze IL-1β concentration via ELISA. The data were analyzed as a factorial design with repeated measures using PROC MIXED in SAS. There was an overall diet effect ($P < 0.05$) associated with greater IL1-β in cows fed MET and CHO (1812 pg/mL) compared with CON (1043 pg/mL). Similarly, there was an overal LPS effect ($P < 0.05$) with control incubations averaging 52 pg IL1-β/mL compared with 1621 and 3013 pg IL1-β/mL in response to 0.01 and 5 μg LPS. The three-way interaction ($P < 0.05$) revealed that the high LPS dose induced a marked response in IL1-β in both MET or CHO regardless of DFP. In contrast, whereas the high dose of LPS induced a similar response (1500–2,000 pg IL1-β) in CON on -15, −7, 7, and 20 DFP, the response on 2 DFP was markedly greater to the point that IL1-β concentration was similar for CON, MET, and CHO. Overall, results confirmed the responsiveness of blood cells to an inflammatory challenge even in a period of immune suppression. More importantly, data revealed that supplemental methionine or choline during the transition period enhances the PIC response, hence, potentially enhancing the responsivennes to invading pathogens.

Key Words: inflammation, transition period, nutrition

1546 (M260) Amino acid analysis in dairy cow plasma by chloroformate derivatization and gas chromatography. N. E. Lobos[*1], G. A. Broderick[2], P. D. Carvalho[3], D. N. Luchini[4], R. D. Shaver[3], A. H. Souza[5], and M. C. Wiltbank[3], *[1]Dep. of Dairy Science, University of Wisconsin–Madison, Madison, [2]Broderick Nutrition & Research, LLC, Madison, WI, [3]University of Wisconsin, Madison, [4]Adisseo S.A.S., Alpharetta, GA, [5]University of California, Cooperative Extension, Tulare.*

The objective of the experiment was to evaluate gas chromatography (GC) after chloroformate derivatization of AA to quantify dietary effects on plasma AA concentrations in dairy cows. Plasma was obtained from 72 cows participating in a previous trial [Souza et al., J. Dairy Sci. 95(Suppl. 2):353, 2012, abstract] where positive performance effects to Met supplementation were reported. Starting at calving, cows were fed isoenergetic diets formulated to deliver equal metabolizable protein (2875 g MP/d). The control diet (CTR) provided 1.89% Met (% of MP), while the treatment diet (MET) was supplemented with sufficient Smartamine M to increase Met to 2.43% of MP. Results indicated increased milk concentrations of protein (2.92 vs. 2.75%, $P < 0.01$) and SNF (8.73 vs. 8.54%, $P < 0.01$) in cows fed MET. Plasma was harvested from blood samples collected at 50 DIM, and kept frozen at -18°C until analysis. Samples were separated by treatment group (supplemented = 37, control = 35) and combined randomly within parity, into seven plasma composites of four to six cows on each diet. Composites were prepared for GC analysis by using a commercial kit (EZ:faast GC-FID Physiological, Phenomenex). This method involves amino acid collection using solid phase extraction (SPE), derivatization with chloroformate, GC separation in a mid-polar capillary column and flame ionization detection. Quantification was based on area under the curve, using the internal standard ratio method (norvaline). Consistent with performance data, analysis of variance indicated higher plasma free Met levels in MET cows vs. CTR cows (22.9 vs. 16.8 μM, $P < 0.001$). Although the kit manual indicated deproteinization was not required, untreated plasma was difficult to work with because variable plasma concentrations of proteins and phospholipids clogged the SPE resin. Mixing plasma at a 1:1 volume ratio with 5% trichloroacetic acid, followed by centrifugation (12,000 × g), allowed satisfactory SPE of all composites. Ion exchange chromatography coupled with ninhydrin quantification is currently the gold standard for AA analysis. The drawbacks of that methodology are high cost and long runtimes. The modifications to the GC-chloroformate method here presented allow rapid (15 minute) determination of differences in free amino acids in cow plasma at a reasonable cost.

Key Words: rumen-protected, methionine, chromatography

Table 1547.

Variable	Treatments					Contrasts[1]			
	16% CP	14.9% CP+EAA	14.9% CP	13.5% CP +EAA	13.5% CP	1	2	3	4
Urinary N, %	0.15	0.12	0.12	0.11	0.15	< 0.001	< 0.001	> 0.10	> 0.10
Urinary N excretion, g/d	111	113	99	86	100	> 0.10	> 0.10	0.089	0.076
Urine N/N intake, %	18.6	20.7	18.0	16.7	20.1	> 0.10	> 0.10	0.072	0.024
Urea N/total urinary N, %	91	80	77	74	73	0.005	< 0.001	> 0.10	> 0.10
Fecal N, %	2.92	2.88	2.84	2.73	2.86	> 0.10	> 0.10	> 0.10	> 0.10
Fecal N excretion, g/d	199	191	196	172	187	> 0.10	> 0.10	> 0.10	> 0.10
Feces N/N intake, %	34	35	35	34	36	> 0.10	> 0.10	> 0.10	> 0.10

[1] Contrasts: 1 = 16 vs. 14.9; 2 = 16 vs. 13.5; 3 = 14.9 vs. 14.9+EAA; 4 = 13.5 vs. 13.5+EAA

1547 (M261) Effects of supplementing limiting amino acids in diets with reduced CP on nitrogen excretion. M. A. C. Danes*[1], G. A. Broderick[2], and C. Parys[3], *[1]University of Wisconsin–-Madison, Madison, [2]Broderick Nutrition & Research, LLC, Madison, WI, [3]Evonik Industries AG, Hanau, Germany.*

Lowering dietary CP content while supplementing limiting essential amino acids (EAA) has potential to increase N efficiency and decrease N excretion. Ten Holstein cows were blocked by DIM into two 5x5 Latin squares with 5 treatments: (1) positive control (16% CP); 14.9% CP with (2) or without (3) EAA infusion; or 13.5% CP diet with (4) or without (5) EAA infusion. Diets contained alfalfa silage, corn silage, high moisture corn, canola meal, soybean meal and soybean hulls. The infusion solutions were prepared according to AminoCow to provide all limiting EAA and infused continuously into cows' abomasum. Amounts of Met, Lys, His, Leu and Val were, respectively, 11, 11, 5, 5, and 0 g/d for treatment 2 and 15, 27, 11, 22, and 6 g/d for treatment 4. Data from the last 4 d of each 14-d period were analyzed using Proc Mixed. Dry matter intake was not different among treatments ($P > 0.10$) and was highly variable. Therefore, DMI was included in the model to isolate treatment effects. Significance was declared at $P < 0.10$. Contrasts and LS-means are reported. There was no difference among treatments for fecal N excretion. Increasing CP level increased urinary N content and proportion of urea in total urinary N. The EAA infusion on 14.9% CP increased urinary N excretion relative to the same diet without infusion. However, when infused on the 13.5% CP diet, EAA decreased urinary N excretion relative to the same diet without infusion. This suggested that the 14.9% CP diet provided sufficient EAA for milk protein synthesis, while the 13.5% CP diet was EAA deficient and supplementation improved N utilization.

Key Words: amino acid infusion, nitrogen excretion, protein

1548 (M262) Effects of rumen-protected ã-aminobutyric acid on immune function and antioxidant status in heat-stressed dairy cows. J. Cheng[1,2,3], N. Zheng[1,3,4], X. Sun[1,2,3], D. P. Bu[3], L. Pan[3], and J. Wang*[1,3,4], *[1]Ministry of Agriculture–Laboratory of Quality and Safety Risk Assessment for Dairy Products, Beijing, China, [2]College of Animal Science and Technology, Anhui Agricultural University, Hefei, China, [3]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [4]Ministry of Agriculture– Milk and Dairy Product Inspection Center, Beijing, China.*

This experiment was conducted to investigate the effects of rumen-protected γ-aminobutyric acid (GABA) on immune function and antioxidant status in heat-stressed dairy cows. Sixty Holstein dairy cows (141 ± 15 DIM, 35.9 ± 4.3 kg of milk/d) were randomly assigned to 1 of 4 treatments according to a randomized complete block design. Treatments consisted of 0, 40, 80, or 120 mg GABA/kg DM from rumen-protected GABA. The trial lasted 10 wk. The average temperature-humidity indices at 0700, 1400, and 2200 h were 78.4, 80.2 and 78.7, respectively. Blood samples were collected from all of animals via tail vein before the morning feeding on d 0, 21, 42, and 56. Data were analyzed by MIXED model procedure of SAS. Concentrations of immunoglobulin (Ig) A (0.18 and 0.25 vs. 0.16 mg/mL) and IgG (64.62 and 62.14 vs. 32.08 μg/mL) increased ($P < 0.05$) in cows fed 80 or 120 mg/kg GABA, while IgM level showed no difference ($P > 0.05$) when compared with control cows. Compared with control, concentrations of IL-2 (10.84 and 9.37 vs. 6.37 ng/mL) and IL-4 (76.72 and 85.64 vs. 56.63 pg/mL) were higher ($P < 0.05$) in cows fed 80 or 120 mg/kg GABA, and the IL-6 level was higher (124.24 vs. 77.53 pg/mL; $P < 0.05$) in cows fed 120 mg/kg GABA, tended to be higher (89.42 vs. 77.53 pg/mL; $P < 0.10$) in cows fed 80 mg/kg GABA. The TNF-α level was higher (68.50 and 80.82 vs. 49.18 fmol/mL; $P < 0.05$) in cows fed 80 or 120 mg/kg GABA, and tended to be higher (62.29 vs. 49.18 fmol/mL; $P < 0.10$) in cows fed 40 mg/kg GABA. The proportions of $CD4^+$ (9.26 and 9.88 vs. 7.03%) and $CD8^+$ (6.41 and 6.26 vs. 5.15%) T lymphocyte were higher ($P < 0.05$) in cows fed 80 or 120 mg/kg

GABA compared with control, but ratio of $CD4^+/CD8^+$ was not different ($P > 0.05$) among treatments. Compared with control, the activities of SOD (9.59 and 9.52 vs. 8.54 U/mL) and T-AOC (6.11 and 5.64 vs. 3.20 U/mL) increased ($P < 0.05$) in cows fed 80 or 120 mg/kg GABA, but the activities of GSH-Px and MDA were not affected ($P > 0.05$) by GABA supplementation. These results indicate that rumen-protected GABA supplementation to heat-stressed dairy cows can improve the immune function and enhance antioxidant activity.

Key Words: γ-amino butyric acid, immune function, antioxidant activity

1549 (M263) Effects of supplemental rumen-protected methionine and histidine on performance of lactating dairy cows. W. D. Weich*[1], K. F. Kalscheur[1], K. J. Herrick[2], and K. E. Griswold[3], *[1]South Dakota State University, Brookings, [2]Kemin Industries, Inc., Des Moines, IA, [3]Kemin Animal Nutrition and Health, Des Moines, IA.*

Objectives were to determine the effects of rumen-protected methionine (MET) and histidine (HIS) on lactation performance. Twenty-seven multiparous and sixteen primiparous dairy cows blocked by parity, milk production, DIM and breed were assigned a treatment in a randomized complete-block design. Cows were fed a covariate diet for 10 d followed by 4 wk of experimental diets. Treatments were: 1) control diet (CON; formulated for 50.5 g MP MET), 2) CON + encapsulated MET (EM; 18 g of product, +10.8 g MP MET), 3) CON + spray-freeze MET (SFM; 33 g of product, +10.8 g MP MET), 4) SFM + encapsulated HIS (SFMH; 120 g of product, +10.1 g MP HIS). Diets were formulated using AMTS (Version 3.4.7.1). The control diet was balanced to contain 14.7% CP (91% of MP requirements) and maintained a LYS:MET ratio of 3.46:1. Addition of MET products reduced the LYS:MET ratio to 2.85:1. The control diet was created as a single batch in a vertical mixer and rumen-protected amino acids were added to CON at the Data Ranger to create treatments. Amino acid supplementation did not affect DMI, milk yield, feed efficiency, milk protein content or yield. Milk fat concentration and yield were greater ($P < 0.05$) for CON compared with EM and SFM. Differences in MUN among EM, SFM, and SFMH may be related to rumen digestibility of the products. Addition of rumen-protected MET or HIS for cows fed a 14.7% CP diet did not alter production performance.

Key Words: histidine, metabolizable protein, methionine, rumen-protected amino acid

Table 1549.

Item	Treatment				SEM	Contrast[1]
	CON	EM	SFM	SFMH		
DMI, kg/d	27.99	27.69	26.85	27.28	0.70	–
Milk, kg/d	35.30	35.31	35.10	35.20	0.75	–
ECM, kg/d	38.07	36.69	36.25	35.75	0.89	–
ECMFE	1.38	1.33	1.37	1.34	0.03	–
Fat, %	4.03	3.76	3.64	3.80	0.14	A
Fat, kg/d	1.40	1.30	1.25	1.28	0.06	A
Protein, %	3.27	3.23	3.29	3.29	0.05	–
Protein, kg/d	1.15	1.11	1.14	1.14	0.03	–
MUN, mg/dL	10.00	9.97	10.63	10.94	0.13	b, d

[1] SFM vs. SFMH. Uppercase = $P < 0.05$, lowercase = $0.05 < P < 0.10$.

1550 (M264) Canola meals from different plants over two production years differ in rumen-undegraded protein. G. A. Broderick*[1], S. Colombini[2], A. Faciola[3], and M. A. Karsli[4], *[1]Broderick Nutrition & Research, LLC, Madison, WI, [2]University of Milan, Italy, [3]University of Nevada, Reno, [4]Kirikkale University, Turkey.*

Lactation trials showed improved production and N efficiency when dietary soybean meal was replaced with equal CP from canola meal. Three canola meal samples were collected from each of 12 Canadian production plants over 2 yr (total = 72) and analyzed for chemical composition and ruminal protein degradability. The Michaelis-Menten inhibitor in vitro method was used to quantify protein degradation rates and rumen-undegraded protein (RUP), assuming passage rates of 0.16/h and 0.06/h for soluble and insoluble proteins. Differences among plants were assessed using the SAS Mixed model; LS-means for plants over both years, and for each year, are reported in Table 1550. Although CP concentration and NDIN and RUP proportions were unaffected by year ($P \geq 0.21$), NDF and soluble N were lower ($P \leq 0.01$) in canola meal produced in 2011 than 2012. Proportions of NDIN ranged from 18 to 28% of total N but were unaffected by plant ($P = 0.15$). However, differences were detected among plants in CP and NDF concentrations ($P \leq 0.03$) and proportions of soluble N and RUP in total N ($P < 0.01$). Plant x year interactions ($P \leq 0.04$) also were found for concentrations of CP and NDF and proportions of NDIN and RUP, but not for soluble N ($P = 0.19$). Results indicated that differences in canola meal RUP concentration were consistent over 2 production years and, depending on plant of origin, ranged from 38 to 50% of CP, a difference of 30%.

Key Words: canola meal, inhibitor in vitro, rumen-undegraded protein

Table 1550. Mean composition of canola meals from two production years

Plant	CP, % of DM	NDF, % of DM	NDIN, % TN	Sol-N, % TN	RUP, % TN
1	42.8^{ab}	25.7^{cd}	17.7	37.1^{a}	40.1^{ef}
2	41.2^{e}	27.1^{bcd}	24.8	21.3^{de}	42.9^{de}
3	41.7^{de}	26.7^{bcd}	22.9	22.1^{de}	45.4^{cd}
4	43.2^{a}	25.3^{d}	21.2	25.5^{cd}	43.1^{de}
5	42.0^{cd}	27.7^{abc}	20.2	19.5^{e}	49.7^{a}
6	42.7^{abc}	27.0^{bcd}	22.8	28.0^{bc}	47.8^{abc}
7	40.2^{f}	26.0^{bcd}	18.4	30.2^{bc}	40.4^{ef}
8	42.2^{bcd}	27.5^{abcd}	23.2	27.8^{bc}	41.1^{ef}
9	41.3^{e}	29.3^{a}	27.7	32.5^{ab}	46.3^{bc}
10	43.3^{a}	26.3^{bcd}	19.9	32.7^{ab}	38.2^{f}
11	41.5^{de}	25.8^{bcd}	18.3	28.7^{bc}	42.2^{e}
12	37.8^{g}	27.8^{ab}	23.1	21.2^{de}	49.3^{a}
Prob-Plant	< 0.01	0.03	0.15	< 0.01	< 0.01
2011	41.7	25.8	20.9	25.6	43.5
2012	41.7	27.8	22.5	28.8	44.3
Prob-Year	0.84	< 0.01	0.27	0.01	0.21
Plant*Year	< 0.01	< 0.01	0.04	0.19	< 0.01

$^{a-f}$ Means within columns with different superscripts differ ($P < 0.05$).

1551 (M265) Rumen-undegradable protein of blood meal, canola meal, low-fat distillers dried grain with solubles, soybean meal, and expeller soybean meal determined using in situ and in vitro ammonia release procedures. H. A. Paz Manzano*[1], T. J. Klopfenstein[1], and P. J. Kononoff[2], *[1]University of Nebraska-Lincoln, Lincoln, [2]University of Nebraska, Lincoln.*

Two Holstein cows (days in milk 70 ± 17 and milk yield 27.3 ± 8.00 kg) fitted with ruminal cannulas were used to determine rumen-undegradable protein (RUP) using an in situ incubation of 16. In addition, the in vitro ammonia (NH_3) release procedure was used to estimate RUP. The in vitro NH_3 release procedure involves the incubation of equal amounts of N from each feedstuff in ruminal fluid and the measurement of the NH_3 and total VFAs produced. Concentrations of $NH_3$and total VFA were adjusted for a blank (only inoculum). The feedstuffs evaluated were: 3 sources of blood meal (BM1, BM2, and BM3), canola meal (CM), low-fat distillers dried grains with solubles (LFDG), soybean meal (SBM), and expeller soybean meal (ESBM). Data from the in situ procedure were analyzed as a randomized complete block design and the model included the fixed effect of feedstuff and the random effects of replicate and load within feedstuff and data from the in vitro ammonia release were analyzed as a complete randomized design and the model included the fixed effect of feedstuff and the random effect of load within feedstuff. Based on the in situ procedure, RUP was 70.2, 63.0. 59.3, 31.2, 24.3, 23.1, 14.7 ± 3.93% crude protein (CP) for BM2, ESBM, BM3, SBM, CM, LFDG, and BM1, respectively. Based on the in vitro ammonia release procedure, RUP was 67.6, 67.5, 65.8, 48.8, 32.5, 32.3, 32.1 ± 3.46% CP for BM2, BM3, ESBM, LFDG, BM1, SBM, and CM. Compared to RUP values obtained from the in situ procedure, values of RUP from the in vitro ammonia release procedure were greater ($P = 0.01$) for BM1 and LFDG and similar ($P \geq 0.10$) for the remaining feedstuffs. The in vitro ammonia release procedure is a promising method for measuring RUP that avoids the use of cannulated animals and errors that may emerge with washout of residue from the polyester bags, and allows for uniform settings; however, more research is needed to elucidate the factors that cause variability when using this procedure.

Key Words: rumen-undegrabable protein, in situ, in vitro

1552 (M266) Sources of protein and protected methionine on in situ ruminal degradability of crude protein of feed ingredients. F. D. O. Scarpino van Cleef*[1,2], J. M. Bertocco Ezequiel[1], E. Neves Muniz[3], R. L. Galati[4], and E. H. C. B. Van Cleef[1,5], *[1]UNESP, Jaboticabal, Brazil, [2]CNPq, Brasilia, Brazil, [3]Embrapa Tabuleiros Costeiros, Aracaju, Brazil, [4]Federal University of Mato Grosso, Cuiaba, Brazil, [5]FAPESP, Sao Paulo, Brazil.*

The objective of this study was to evaluate crude protein degradability of feed ingredients in diets containing corn gluten or starea as protein sources, with or without 2 g/d protected methionine. Eight male ruminally-cannulated sheep (12 mo old, 51.3 kg BW) were assigned to a replicated 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments (two sources of protein— corn gluten or starea— and with or without protected methionine). The in situ nylon bag technique was used in this trial. Samples of feed ingredients were ground to 5 mm (corn silage), and 2 mm (extruded corn and soybean hulls), and incubated for 6, 12, 24, 48, 72, and 96 h for corn silage, and 1, 6, 12, 24, and 48 h for extruded corn and soybean hulls. Data were fitted to exponential model to estimate degradation parameters, and effective degradability was calculated with passage rates of 2, 5, and 8%/h. Data were analyzed as a replicated 4 × 4 Latin square with PROC MIXED of SAS. There was no interaction of protein sources and protected methionine, thus only the main effects were studied. Variations from 23 to 91% (corn gluten, and starea, respectively) on protein degradability of protein sources do not affect degradability parameters, potential degradability, and effective degradabilities (2, 5, and 8%/h passage rates) of corn silage and soybean hulls. The average potential degradabilities of crude protein observed were 75.9% (corn silage), and 73.6% (soybean hulls). The average effective degradabilities of crude protein for 3, 5, and 8%/h passage rates were respectively 71.6, 68.8, and 67.7% (corn silage), and 66.1, 58.0, and 53.1% (soybean hulls). The addition of protected methionine improves in 4% the potential crude protein degradability and in 2.8, 2.1, and 1.5% the effective degradabilities of corn silage, for 2, 5, and 8%/h passage rates, respectively. It was concluded that regarding fibrous in-

gredients, the variation of 68% units in crude protein degradability of protein sources is not enough to modify the ruminal utilization of crude protein of these ingredients. Furthermore, the protected methionine inclusion improves crude protein degradation parameters for low protein ingredients.

Key Words: degradability, methionine, protein sources

1553 (M267) Supplementation of lysine and methionine in the starter concentrate or milk replacer of dairy calves.

J. T. Silva*, M. R. De Paula, G. Santos, G. Slanzon, and C. M. M. Bittar, *University of Sao Paulo, Piracicaba, Brazil.*

Concentrate and milk replacer available in Brazil are deficient in lysine and methionine for dairy calves, which may benefit from supplementation. Forty-five newborn Holstein male calves were used in a randomized complete block designed experiment and assigned into one of three treatments: 1) Control: no amino acid (AA) supplementation; 2) Starter concentrate: supplementation of lysine and methionine in the concentrate starter to reach daily intakes of 17 g/d and 5.3 g/d, respectively; and 3) Milk replacer: supplementation of lysine and methionine in the milk replacer to reach daily intakes of 17 g/d and 5.3 g/d, respectively. Calves were housed in individual shelters, with free access to water, and were fed starter concentrate and 6 L/d of milk replacer (20% CP, 16% ether extract, and 12.5% solids), divided into two meals, until the 8 wk of life, when they were weaned. Starter concentrate and milk replacer intakes, as well as fecal scores were monitored daily. Body weight, withers height, heart girth and hip width were weekly measured. Data suggest that amino acid supplementation in the concentrate decreased solid feed intake, reducing total dry matter intake after weaning and consequently calves' final body weight (Table 1553). Amino acid supplementation have no beneficial effects on dairy calves' performance.

Key Words: amino acids, growth, milk-feeding period

Table 1553. Performance of dairy calves receiving starter concentrate or milk replacer supplemented with lysine and methionine

	Control	Starter Concentrate	Milk replacer	SEM	$P <$
Body weight, kg					
Initial	39.5	38.9	41.2	1.69	1.000
At weaning	53.5[a]	47.4 b	48.9[b]	1.68	0.023
Final	61.1[a]	50.6 b	53.4[b]	1.68	0.023
Daily gain, g					
Before weaning	245.2	168.6	173.2	31.46	0.167
After weaning	539.7	214.2	358.8	105.6	0.11
Starter intake, g/d					
At weaning	429.9	155.8	270.1	97.98	0.230
Final	1529.9	1035.9	1278.9	97.98	0.230
Total dry matter intake, g/d					
Before weaning	880.9	805.4	813.0	31.4	0.182
After weaning	1329.9[a]	770.5[b]	1089.6[ab]	146.9	0.04
Feed efficiency, daily gain/total intake	0.26	0.11	0.21	0.05	0.091
Fecal score	1.68	1.92	1.83	0.07	0.077
Height withers gain, cm/week	0.68	0.52	0.59	0.07	0.290
Heart girth gain, cm/week	1.15	0.83	0.89	0.12	0.114
Hip width gain, cm/week	0.30	0.20	0.27	0.06	0.206

[ab] means with different subscripts differ ($P < 0.5$)

1554 (M268) Evaluating the plasma free amino acid dose–response method to determine the content of metabolizable methionine in a rumen-protected methionine supplement.

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The plasma free AA dose–response approach has been proposed as the standardized method for evaluating rumen-protected Lys supplements. The method has the advantage of providing animal-derived estimates of efficacy under conditions of commercial use. However, before using the approach for evaluating rumen-protected Met (RP-Met) supplements, it is necessary to confirm that a positive linear relationship exists between increasing amounts of absorbed Met and plasma Met concentrations. The primary objective of this experiment was to confirm linearity in plasma Met response with up to 24 g/d of supplemental MP-Met by abomasal infusion or feeding a RP-Met product. A secondary objective was to determine if technique precision could be improved by including the other plasma sulfur AA (cystine, cystothionine + allocystothionine, homocystine and taurine) with Met (total sulfur AA) as an indicator of Met absorption. Five rumen-cannulated lactating Holstein cows (90–155 DIM), fed a Met-deficient diet, were assigned to a 5 × 5 Latin square with 7-d experimental periods. Treatments (*P*er 25.0 kg/d of DMI) were 0 g/d Met (neg-

ative control), 12 and 24 g/d abomasally infused Met, and 12 and 24 g/d of assumed MP-Met from a RP-Met supplement. Blood samples were taken from the tail vein every 2 h, 4 times daily, the last 3 d of each period, centrifuged, deproteinized, and composited into 1 daily sample/cow. Data for plasma AA concentrations were analyzed using the PROC MIXED and PROC REG procedures of SAS 9.2. The basal diet was confirmed to be Met-deficient by observed increases in milk protein concentration (+0.10 and 0.12% units for infused and fed Met, respectively; $P < 0.05$) with the first level of both infused and fed Met. All plasma sulfur AA responded in a significant linear fashion to both infused and fed Met ($P < 0.05$). Estimates of the MP-Met content of the RP-Met supplement were the same using either plasma Met or plasma total sulfur AA. The plasma free AA dose–response method is applicable for determining the MP-Met content of RP-Met supplements.

Key Words: rumen-protected, methionine, evaluation

1555 (M269) Amino acids supplementation in the milk replacer for dairy calves.

J. T. Silva*, N. B. Rocha, E. Miqueo, T. Manzoni, G. Santos, S. Baldassin, and C. M. M. Bittar, *University of Sao Paulo, Piracicaba, Brazil.*

This study evaluated the performance and fecal scores of dairy calves receiving milk replacer supplemented with lysine and methionine (EAA) to reach daily intakes of 17 g/d and 5.3 g/d, respectively; and two levels of AminoGut (Ajinomoto Animal Nutrition; 10% Glutamine and 10% Glutamic acid). Forty-five newborn Holstein male calves were utilized in a randomized blocks experimental design, and distributed into three treatments: 1) Control: no amino acid supplementation; 2) AminoGut 0.6%: supplementation of EAA and 0.6% AminoGut; and 3) AminoGut 1%: supplementation of EAA and 1% AminoGut. Calves were individually housed, with free access to water and starter concentrate, and received 6L/d of milk replacer (20CP:16EE; 12.5% solids), until the eighth week of life, when weaned. Calves were followed up to the 10 wk of life. Feed intakes and fecal scores were monitored daily; while body weight and body measurements were weekly measured. Even though AminoGut has been proven to benefit animals affected diarrhea, there were no supplementation effects on fecal scores. Supplementation of 0.6% of glutamate increased starter intake, which may benefit animals going through the transition period. However, the low intake observed for all treatments resulted in modest daily gains and final weight, as it has been seen in other trials during summer tropical conditions. *Supported by Fapesp, São Paulo, Brazil.*

Key Words: glutamate, lysine, methionine

Table 1555. Performance of calves receiving milk replacer supplemented with lysine + methionine, and two levels of AminoGut

	Control	AminoGut 0.6%	AminoGut 1%	SEM	$P <$
Body weight, kg					
Initial	37.0	36.8	38.0	1.3	0.089
At weaning	48.2	48.3	47.2	1.9	0.089
Final	54.8	56.1	54.8	2.5	0.089
Daily gain, g					
Before weaning	246.8	270.6	218.7	48.3	0.756
After weaning	430.7	548.4	560.2	79.2	0.418
Starter intake, g/d					
At weaning	104.6 b	280.7 a	248.9 ab	58.1	0.051
Final	1400.3	1226.9	1299.8	206.5	0.270
Total dry matter intake, g/d					
Before weaning	786.5	843.1	806.0	40.6	0.615
After weaning	926.3	1089.3	1077.8	133.9	0.622
Height withers, cm	0.6	0.8	0.7	0.09	0.478
Heart girth, cm	1.3	1.2	1.1	0.17	0.846
Hip width, cm	0.3	0.3	0.3	0.04	0.825
Fecal score	1.8	1.9	1.9	0.08	0.398

[ab] means with different subscripts differ ($P < 0.5$)

1556 (M270) Effects of maternal nutrition and arginine supplementation on characteristics of wool quality in offspring.

J. L. Peine*, P. P. Borowicz, J. S. Caton, and R. R. Redden, *North Dakota State University, Fargo.*

The objectives of this study were to measure effects of maternal nutrition and rumen-protected arginine supplementation on postnatal offspring wool quality and follicle development. We hypothesized that lambs from ewes receiving diets fed to nutrient requirements would have a greater density of wool follicles and improved wool quality compared to lambs from nutrient restricted ewes. We also hypothesized that lambs from restricted ewes receiving a rumen-protected arginine supplement would present similar wool follicle numbers and quality to those lambs from adequately fed dams. To test these hypotheses, multiparous Rambouillet ewes ($n = 32$; 67.6 ± 6.2 kg) were randomly assigned to one of three treatments at 54 ± 3.9 d of gestation in a completely random design. Dietary treatments included 100% nutrient requirements (control, CON), 60% of CON nutrients (restricted, RES), and RES with the addition of a rumen-protected arginine supplement dosed at 180 mg/kg of body weight once daily (RES-ARG). Ewes were penned individually in a temperature-controlled facility. Immediately post-lambing, lambs were separated from ewes and raised independent of their dam until necropsy at 54 ± 3 d of age. A wool sample was taken for quality analysis, in addition to skin samples (3 cm^2) from the side (between the 10th and 12th rib) and britch regions. Following histological preparation and stereological analysis all data were analyzed using the PROC MIXED of SAS. No differences were observed in follicle numbers between treatments for skin samples taken from

the side of the lambs ($P \geq 0.17$). However, in the britch samples lambs from RES-ARG ewes had more ($P = 0.02$) follicles present than lambs from CON ewes, with lambs from RES being both intermediate and similar in follicle number (106 vs. 86 vs. 93 ± 6.3 follicles per 1 mm^2, respectively). There were no differences among treatments for wool quality measures of mean fiber diameter, fiber diameter SD, or comfort factor ($P \geq 0.32$). These data partially support our hypothesis that maternal rumen-protected arginine supplementation may increase the number of developing follicles in offspring, and therefore potentially increase wool production. However, we reject our hypothesis that arginine supplementation will increase wool quality in those lambs from restricted-nutrient dams.

Key Words: arginine, wool, developmental programming

1557 (M271) Effects of maternal nutrition and rumen-protected arginine supplementation on postnatal lamb performance and organ mass. J. L. Peine*, G. Jia, S. T. O'Rourke, L. P. Reynolds, and J. S. Caton, *North Dakota State University, Fargo.*

Our hypothesis was that rumen-protected arginine supplementation would overcome the negative effects of restricted maternal intake during the last two-thirds of gestation on lamb organ mass and postnatal performance. To investigate the effects that arginine supplementation would have, $n = 32$ multiparous, Rambouillet ewes were allocated to one of three treatments in a completely random design at 54 ± 3.9 d of gestation. Dietary treatments included either 100% of requirements (control, CON), 60% of control (restricted, RES), or RES plus a rumen-protected arginine supplement dosed at 180 mg/kg BW once daily (RES-ARG). Ewes were penned individually in a temperature controlled facility, and remained on these treatments through parturition. Upon parturition, lambs were immediately removed from their dam and reared independently. At 54 ± 3 d of age, lambs were necropsied and organs were dissected. Birth weights in lambs from CON ewes were greater ($P = 0.04$) than lambs from RES ewes, with lambs from RES-ARG ewes being intermediate (5373, 4553, and 4697 ± 256.0 g, respectively). At 54 ± 3 d of age, curved crown rump measurements were longer ($P = 0.003$) in lambs from RES-ARG ewes than from RES, with a tendency for lambs from RES-ARG ewes to also be longer ($P = 0.06$) than CON (99.8 vs. 93.9 vs. 96.3 ± 1.28 cm, respectively). Organ mass measurements showed lambs from RES-ARG ewes had greater ($P = 0.05$) liver mass than RES, with lambs from CON ewes being intermediate (490.0 vs. 481.2 vs. 429.5 ± 21.08 g, respectively). In addition, lambs from CON ewes had greater ($P = 0.01$) mass of adrenal glands than lambs from RES ewes. These data support that rumen-protected arginine supplementation may partially mitigate negative effects on postnatal lamb performance and organ mass due to restricted maternal intake during the last two-thirds of gestation.

Key Words: arginine, developmental programming, offspring

1558 (M272) Ultrasonography for investigating the effect of supplementing whole milk with plant-derived complex carbohydrates on curd clearance through the abomasum of dairy calves. K. Singh*[1], S. R. Leath[1], H. V. Henderson[1], T. J. Watson[1], D. Pacheco[2], and C. D. McMahon[1], *[1]AgResearch Ltd, Ruakura Research Centre, Hamilton, New Zealand, [2]AgResearch Ltd, Grasslands, Palmerston North, New Zealand.*

Growth rates of dairy heifer calves and their performance at first lactation are enhanced by supplementing a whole milk diet with plant-derived complex carbohydrates and specific amino acids. At present it is unclear how such changes in nutrition from birth to weaning can affect a dairy cow's subsequent lactations. The aim of this study was to establish the use of ultrasound to investigate if the transit time of milk is influenced by a supplement of plant-derived complex carbohydrates to whole milk. Initially, the use of ultrasonography for detecting curd after feeding whole milk in the abomasa of pre-ruminant dairy heifer calves ($n = 10$) was determined. This was conducted using a sectorial probe (M-Turbo with C60x/5.2MHz transducer; Sonosite USA), at -10, 5, 30, 60, and 120 min after feeding. A score system was developed for fullness of the abomasum (0 to 3) and size of the curds (A to C). In trial 2, 22 calves were individually fed whole milk (control group) until weaning (approximately 80 kg live weight); 4L whole milk per day (2L am and 2L pm) using an automated calf feeder. The remaining calves (supplemented group; $n = 21$) were fed as per above, but whole milk was supplemented with a probiotic (X-Factor [XF], Bell-Booth Ltd, New Zealand) until 18 d of age and then XF was replaced with a source of plant-derived complex carbohydrates and selected amino acids (Queen of Calves [QoC], Bell-Booth Ltd) at a starting dose of 25 g/L whole milk, increasing at d 20 of age to 37.5 g/L, and to 50 g/L from d 21 of age until weaning. The groups were balanced for age, weight and breed. Ultrasonography of the abomasum was conducted as above. Supplementing whole milk with XF did not affect average retention time compared with calves fed whole milk. However, milk supplemented with QoC delayed the transit time of curd 1.4 ± 0.28 h (32%) longer ($P < 0.001$) at 4 wk of age and 0.7 ± 0.34 h (14%) longer ($P = 0.05$) at 8 wk of age, compared with calves fed whole milk alone. These data indicate that milk supplemented with QoC slows transit time of curd in the abomasum, which may allow a greater absorption of nutrients to support early growth.

Key Words: curd, transit time, dairy heifer

1559 (M273) Relationship between non-protein nitrogen and true protein in supplements during the post-weaning phase of Nellore steers in the dry-wet season transition.
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The objective of this study was to evaluate the effect of different levels and rates of protein degradation on the performance of Nellore, recreated on *Brachiaria brizantha* cv. Marandu during the transition period dry water. Seventy-two bulls were used with 412.45 kg body weight (BW) initial, non-castrated Nellore, daily receiving 3 g/kg BW of supplement, these were divided into 12 paddocks. The treatments were: energy protein supplement (SPE) with 25% CP (control), energy protein supplement with 40% CP, one third of the PB of vegetable and two thirds of chemical origin, Supplement energy protein with 40% CP, with two thirds of the PB of vegetable and one third of chemical origin, energy protein supplement with 40% CP, one half PB of plant origin and half of chemical origin. The animals were weighed every 28 d after 16 h of fasting and liquid to obtain the average daily gain (ADG). The experiment took place from September to December 2013, totaling am 84-d evaluation. The experimental unit used was the picket, which is composed of six testeres animals. The experimental design was a randomized block experimental areas and the blocking factor, there were three paddocks per treatment. Data were analyzed using mixed model using the PROC MIXED of SAS software, version 9.2 (SAS, 2008), the 10% level of significance by *t* test. The increase in NNP (40–2/3NNP) depressed ADG ($P = 0.07$) 0.265 kg/day in compared to other treatments with averaged 0.366 kg, 0.419 kg and 0.399 kg for C-25, 40–1/2 NNP and 40–1/3 NNP, respectively. The final body weight was greater ($P = 0.08$) in animals that received 40–1/2 NNP (416.7 kg) compared to those who received C-25 (408.5 kg) or 40–2/3 NNP (404.4 kg). The 40–1/3 NNP treatment with intermediate weight (413.1 kg) did not differ from treatments 40–1/2 NNP ($P = 0.40$) and C-25 ($P = 0.30$). It is concluded that supplementation with 40% CP and one-half NNP is able to generate heavier animals in the transition dry-waters. *Supported by CNPq and Bellman.*

Key Words: average daily gain, *Brachiaria brizantha,* supplementation

1560 (M274) Sulfur sources in protein supplements and their influence on amino acid profiles.
F. P. Leonel[*1], C. J. Silva[2], L. M. Moreira[1], J. M. Carvalho[1], J. C. Carvalho[3], J. C. Pereira[3], T. C. Nunes[1], and R. A. Vieira[4], *[1]Federal University of São João del Rei (UFSJ), Brazil, [2]National University of Brasília, Brazil, [3]Federal University of Viçosa (UFV), Brazil, [4]Norte Fluminense State University, Campos dos Goytacazes, Brazil.*

The present experiment was performed to evaluate the effect of different sulfur sources in protein supplements for cattle in the amino acids profile with respect to the abomasal digesta. Crossbred steers were fed with *Brachiaria dictyoneura* hay, applying different sulfur sources in the protein supplement: 70S elementary sulfur- byproduct (ES70S); 98S elementary sulfur- flowers of sulfur (ES98S); hydrated calcium sulfate (HCS); anhydrous calcium sulfate (ACS) and ammonium sulfate (AS). The dietary treatments were applied at 11:1 nitrogen:sulfur ratio. Five steers which were fistulated in the rumen and abomasum were used in a 5 × 5 Latin square design. The experiment had five 16-d periods, in which the first 10 d were for adaptation period and the subsequent 6 d were utilized to obtain the experimental data. The concentration of available amino acids in the abomasal digesta (g/kg DM) remained with very similar values ($P > 0.05$) in the evaluated diets. The amino acids evaluated in the abomasal digesta remained with the same quantitative profiles, suggesting that their properties do not depend on the sulfur sources encountered in the respective diets.

Key Words: beef steers, amino acid profiles, sulfur nitrogen ration

Table 1560. Amino acid profile in abomasal digesta in different treatments and their coefficient of variation (CV%)

	E70S	E98S	HCS	ACS	AS	CV(%)
	—— mg/kg of DM ——					
Essential amino acids						
Valine	19.52	18.80	18.64	18.96	19.40	10.65
Methionine	20.40	19.82	19.70	19.94	20.30	11.36
Isoleucine	5.46	5.60	5.68	5.52	5.70	18.03
Leucine	18.16	18.38	18.72	18.58	20.22	17.22
Phenylalanine	32.04	30.68	31.86	31.74	32.46	13.68
Histidine	541.54	541.76	529.08	552.12	590.66	14.16
Valine	7.22	7.02	7.12	7.42	7.56	13.24
Lysine	34.92	33.72	34.04	35.28	36.22	14.83
Arginine	18.52	18.04	18.80	18.78	19.16	10.28
Nonessential amino acids						
Aspartic acid	45.34	44.06	44.30	43.80	44.96	12.08
Serina	100.42	101.24	107.62	149.18	114.10	32.64
Cystine	5.58	5.44	5.00	5.24	5.54	12.66
Glutamic acid	45.82	46.38	45.64	45.30	46.98	15.72
Proline	20.30	19.74	19.74	20.20	20.76	13.34
Glycine	21.06	19.98	20.68	19.64	19.86	15.15
Alanine	26.66	25.06	25.18	24.98	26.02	12.45

1561 (M275) Slow-release urea in diets of crossbred lactating cows. F. P. Leonel[*1], B. T. Santiago[2], S. D. J. Vilella[2], J. M. Carvalho[1], J. C. Carvalho[3], M. M. Assis[1], T. C. Nunes[1], and L. M. Moreira[1], [1]*Federal University of São João del Rei* (*UFSJ), São João del Rei, Brazil,* [2]*Federal University of Vales do Jequitinhonha e Mucuri* (*UFVJM), Diamantina, Brazil,* [3]*Federal University of Viçosa* (*UFV), Brazil.*

This work was performed to evaluate the performance of F1 lactating cows (Holstein x Zebu) in response to different levels of substitution of soybean meal by non-protein nitrogen equivalent protein derived from slow-release urea (SRU). Eight cows were used in a duplicate 4 × 4 Latin square design, according to the following treatments: control (100% soybean meal and 0% SRU), 34SRU (66% soybean meal and 34% SRU), 66SRU (34% soybean meal and 66% SRU) and 100SRU (0% soybean meal and 100% SRU). The forage sorghum silage was used. Intakes of dry matter (DMI), crude protein (CPI), neutral detergent fiber (NDFI) were measured. The apparent digestibility of dry matter (MDad) and neutral detergent fiber (NDFad) were evaluated using chromic oxide as an external marker. Milk production was measured. Data were subjected to analysis of variance using the statistical program SAEG, adopting the 5% level of probability. Treatments did not affect DMI, CPI, and NDFI ($P > 0.05$; Table 1561). The results of apparent digestibility of the dry matter and neutral detergent fiber also do not present differences ($P > 0.05$) between treatments. Milk production and composition demonstrated also similar results ($P > 0.05$), when are compared the treatments evaluated in this work. The replacement of soybean meal by slow-release urea (SRU) does not affect the variables of intake and digestibility of dry matter or milk production of crossbred cows.

Key Words: digestibility, intake, milk production, soybean meal

Table 1561. Intake and digestibility of DM and nutrients and milk production

	Treatments					
Variable	Control	34ULL	66ULL	100ULL	CV (%)	*P*
DMI (kg/dia)	18,20	18,44	18,76	17,99	6898	0555
CPI (kg/day)	2,50	2,65	2,62	2,70	11,207	0678
NDFI (kg/day)	5,92	5,59	6,29	5,63	13,216	1408
DMad (%)	57,78	59,77	57,35	57,74	4213	0235
NDFad (%)	38,89	36,40	34,27	35,29	9860	0101
Milk production (kg/day)	13,39	13,88	13,44	12,05	19,621	0744

[1] DMI = dry matter intake; CPI = crude protein intake; NDFI = neutral detergent fiber intake; DMad = apparent digestibility of dry matter; NDFad = apparent digestibility of neutral detergent fiber; CV = coefficient of variation

1562 (M276) Passage rate and efficiency of microbial protein synthesis in buffaloes fed increasing levels of crude protein. E. Machado, L. M. Zeoula*, E. H. Yoshimura, R. B. Samensari, N. W. Santos, B. C. Agustinho, L. D. M. Pereira, and S. C. Aguiar, *Universidade Estadual de Maringá, Maringá, Brazil.*

Optimization of the ruminal passage rate improves the conditions for growth of rumen microorganisms; however, if the dilution rate is too fast, the microbial growth can be reduced. The objective was to evaluate the effect of increasing levels of crude protein (CP) in the diet of buffaloes on the passage rate and efficiency of microbial protein synthesis (EMPS). Four crossbred growing buffaloes were used, weighing 355 ± 3.5 kg of body weight, cannulated in the rumen and distributed in a 4 × 4 Latin square design. The total mixed ration consisted of corn silage (850 g.kg^{-1}) and concentrate (150 g.kg^{-1}) and was formulated to meet the proposed levels of CP (70, 90, 110, and 130 g.kg^{-1}). To determine the dilution rate, a Co-EDTA solution (32 g of Co-EDTA in 500 mL of distilled water) was added via ruminal cannula before the first feeding. Ruminal fluid was collected at time zero (before the first feeding), and 2, 4, 6, 8, 10, 12, 14, 16, and 24 h post-feeding. To estimate the EMPS, spot urine samples were collected. From the concentration of creatinine in the spot urine sample, the urinary volume was estimated and the production of microbial nitrogen was calculated from the amount of absorbed purines, which was estimated as the excretion of purine derivatives in urine using the following equation: $Y = 0.74X + (0.117 W^{0,75})$. The synthesis of microbial nitrogen in the rumen was calculated as a function of absorbed purines: $Y = X70/0.116 \times 0.83 \times 1000$. Data were interpreted using the SAS statistical software (version 9.0). There was a linear effect ($P < 0.01$) for the levels of CP on microbial production, which averaged 244.8, 342.0, 394.8 and 425.2 g of microbial protein for 70, 90, 110, and 130 g.kg^{-1}PB, respectively. According to the regression equation ($Y = 54.62 + 4.70X$, $R^2 = 0.4555$), we observed an increase of 4.70 units in the microbial production for each percentage unit of dietary CP. However, this effect is not observed on the dilution rate and on the EMPS when expressed per unit of fermented carbohydrate, probably due to the relationship between these two parameters. Therefore, if the increase in the dietary CP did not alter the EMPS, it can be concluded that the rumen microorganisms' requirements were met at the lowest level of dietary protein.

Key Words: transit kinetics, nitrogen, purine derivatives

1563 (M277) Effects of test weight and processing method on in vitro intestinal digestibility of barley grain. Y. Zhao[1], S. Yan[2], Z. He[1], U. Anele[1], M. L. Swift[3], T. A. McAllister[4], and W. Yang[*1], *[1]Lethbridge Research Centre, Agriculture and Agri-Food Canada, AB, [2]College of Animal Science, Inner Mongolia Agricultural University, Hohhot, China, [3]Alberta Agriculture and Rural Development, Lethbridge, Canada, [4]Agriculture and Agri-Food Canada, Lethbridge, AB.*

An in vitro study was conducted to investigate the effects of test weight and processing method on intestinal digestibility of barley grain following ruminal incubation. The study was designed as a 2 × 2 × 2 factorial arrangement with treatments: test weight (TW; low vs. high), precision processing (*P*P; control vs. PP), and processing index (*P*I; 75 vs. 85%). Ten barley samples with 5 low (574 g/L) and 5 high (632 g/L) TW were either dry-rolled with single roller setting (control) or sieved into small and large kernels, then dry-rolled based on kernel size of each fraction (i.e., PP). Each sample was dry-rolled moderately or coarsely with PI of 75 or 85%, respectively. Intestinal DM digestibility (iDMD; % of ruminal residue input) of barley grains was determined using the modified three-step in vitro procedure. Barley samples were incubated in the rumen for 12 h to produce ruminal residues using three beef heifers (650 ± 25 kg BW) fitted with rumen cannula and fed a diet consisting of 70% barley silage and 30% barley grain. Ruminal residues were incubated in 1 N HCl containing 1 g/L of pepsin for 1 h, and then in phosphate buffer (*P*H 7.8) containing pancreatin at 39°C for 24 h. An interaction between TW and PP ($P < 0.02$) and between PP and PI ($P < 0.01$) was detected but not between TW and PI ($P > 0.05$). The iDMD was greater ($P < 0.01$) with high (25.6%) than with low (23.1%) TW of barley grain for control barley, whereas the iDMD was not different between the low (20.2%) and high TW (20.4%) for PP barley. Compared to control processing, PP reduced ($P < 0.01$) the iDMD (*P*P vs. control; 13.5 vs. 21.2%) for processed barley with PI of 85% but not for barley with PI of 75% (27.3%). Decreasing PI from 85 to 75% increased ($P < 0.01$) iDMD from 17.3 to 27.4%. These results indicate that the intestinal digestibility of barley grain varied with TW, processing method, and extent of processing. It suggests that manipulating these factors may partly shift grain starch digestion from the rumen to the intestine, thereby potentially reduce rumen acidosis and improve feed efficiency in feedlot beef cattle fed high-grain diet.

Key Words: barley grain, precision processing, in vitro intestinal digestibility

1564 (M278) Using a fibrolytic enzyme to barley-based finishing diets containing wheat dried distillers grains with soubles: Ruminal fermentation, digestibility, and growth performance in feedlot steers. Z. He[*1,2], M. He[1], N. D. Walker[3], T. A. McAllister[4], and W. Yang[1], *[1]Lethbridge Research Centre, Agriculture and Agri-Food CanadaAB, Canada, [2]Key Laboratory for Agro-Ecological Processes in Subtropical Region, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha, China, [3]AB Vista Feed Ingredients, Marlborough, UK, [4]Agriculture and Agri-Food Canada, Lethbridge, AB.*

Two experiments were conducted to evaluate the effects of adding an exogenous fibrolytic enzyme (FE) on ruminal pH and fermentation, digestibility, and growth performance in feedlot beef cattle fed finishing diet containing wheat dried distillers grains with solubles (DDGS). In Exp. 1, four ruminally cannulated Angus heifers (averaged BW of 807 ± 93.9 kg) were used in a repeated 4 × 4 Latin square design. Treatments were: 1) control (CON; 10% barley silage and 90% barley grain-based concentrate); 2) WDG (CON diet substituting 30% wheat DDGS for barley grain); 3) WDGL (WDG diet supplementing with low FE; 1 mL FE/kg diet DM); and 4) WDGH (WDG diet supplementing with high FE; 2 mL FE/kg diet DM). Heifers were fed at restriction of 90% ad libitum twice daily. Digestibility in the total digestive tract was measured using Yb as external digesta marker. Statistical contrasts were generated to compare CON vs. WDG and the linear and quadratic effects of FE dosages (0, 1, and 2 mL FE/kg diet). Digestibility of DM was less ($P = 0.01$) with WDG (67%) than CON diet (71%). Increasing FE linearly ($P < 0.05$) increased starch digestibility from 88.7, 89.7 to 91.3% without affecting digestibility of other nutrients. Adding FE also reduced ($P = 0.03$) ruminal ammonia-N concentration from 13.6 to 10.1 m*M*. In Exp. 2, one hundred and sixty yearling steers (initial BW of 495 ± 37.9 kg) were fed 1 of 4 diets used in Exp. 1. Dry matter intake (10.9 kg/d), final BW (684 kg), and ADG (1.69 kg) did not differ between steers fed CON and WDG diets. However, steers fed WDG reduced ($P < 0.05$) G:F (150 vs. 160 g/kg DMI) and increased ($P < 0.01$) percentage of abscessed livers (49 vs. 15%) compared to steers fed CON. Increasing FE did not affect DMI, final BW, and ADG but tended ($P < 0.09$) to linearly improve G:F (150 to 157), and decreased ($P = 0.03$) incidence of abscessed livers (49 to 25%). Carcass traits were not affected by treatments. These results indicated that inclusion of wheat DDGS at 30% of the ration DM in finishing diets had adverse impacts on digestibility, feed efficiency and animal health. However, supplementing finishing diet containing wheat DDGS with FE potentially offset the negative effect of including wheat DDGS.

Key Words: feed efficiency, fibrolytic enzyme, finishing feedlot steers

1565 (M279) Effects of forage intake to minimize the risk of subacute ruminal acidosis on performance of feedlot finishing cattle. K. M. Koenig*[1], G. E. Chibisa[1], G. B. Penner[2], and K. A. Beauchemin[1], *[1]Agriculture and Agri-Food Canada, Lethbridge Research Centre, AB, [2]University of Saskatchewan, Saskatoon, Canada.*

Growing beef cattle in North America are typically fed high grain diets with a limited amount of forage to maximize productivity cost-effectively. Distillers grains (DG) are now commonly fed as part of the concentrate lowering the amount of fermentable starch in the diet and the potential risk of ruminal acidosis. The objectives of the study were to determine the effects of varying the concentration of forage in barley-based diets containing DG on feed intake, growth performance, and carcass traits of feedlot finishing cattle. A uniform group of 160 cross-bred beef steers was stratified according to initial BW (349.7 ± 22.3 kg) and randomly allocated to 20 pens (5 pens of 8 steers per treatment). The treatments were barley silage at 0, 4, 8, and 12% of diet DM. The remainder of the diet consisted of 80, 76, 72, and 68% barley grain for the 4 diets, respectively, 15% corn dried DG and solubles, and 5% supplement (with monensin at 28 mg/kg diet DM). The diets were fed as a total mixed ration for ad libitum intake (minimum of 5% orts) once per day. Cattle were weighed on 2 consecutive d at the start and end of the experiment and on 1 d every 3 wk throughout the experiment (124 d). The DMI of each pen was determined from feed offered daily and orts at the end of each 3-wk period. The ADG was determined from linear regression of BW over time. Data for DMI for each pen, and BW, ADG, G:F, and carcass traits for each animal were analyzed as a completely randomized design using a mixed linear model with diet as a fixed effect, pen replicate and diet × pen replicate as random effects (except for the model for DMI), and pen as the experimental unit. There was a trend ($P = 0.10$) towards a linear increase in DMI by steers with increasing percentage of barley silage. However, there was no effect ($P > 0.05$) of the barley silage treatments on final shrunk BW (612.7 ± 4.25 kg), ADG (1.86 ± 0.03 kg/d), and carcass traits. Feed efficiency linearly decreased ($P < 0.05$) with increasing percentage of barley silage. Increasing the proportion of barley silage in a barley grain-based diet with DG may reduce the incidence of subacute ruminal acidosis but feed conversion efficiency is reduced.

Key Words: finishing cattle, forage, growth performance

1566 (M280) Saliva production and short-chain fatty acid absorption in beef cattle fed a low- or high-forage diet. G. E. Chibisa*[1], K. A. Beauchemin[1], and G. B. Penner[2], *[1]Agriculture and Agri-Food Canada, Lethbridge Research Centre, AB, [2]University of Saskatchewan, Saskatoon, Canada*.

Based on past research, there are indications that a potential decrease in acid removal from the rumen via epithelial absorption during a bout of ruminal acidosis could possibly be compensated for by an increase in salivation. However, there is limited information on whether similar changes in the relative contributions of salivary bicarbonate and passive and/or facilitated absorption of short-chain fatty acids (SCFA) to pH regulation occur when dietary forage content is altered. Therefore, the objective of this study was to determine the effects of feeding a low- (LF) or high-forage (HF) diet on ruminal fermentation, salivation and SCFA absorption. Eight ruminally-cannulated cattle were used in a crossover design with 49 d periods. The treatments were barley silage at 30 (LF) or 70% (HF) of dietary dry matter (DM). The LF and HF diets contained 45.3 and 30.9% starch and 26.4 and 38.3% physically effective fiber (DM basis), respectively. On d 35, ruminal fluid was collected to determine SCFA concentration. Ruminal pH was continuously measured from d 29 to 35. Eating or resting salivation, was measured by collecting masticate (d 39 and 40) or saliva samples (d 42 and 43) at the cardia, respectively. On d 42 and 43, the temporarily isolated and washed reticulo-rumen technique was used to measure total, and chloride competitive (an indirect measure of protein-mediated transport), absorption of acetate, propionate and butyrate. Total ruminal SCFA concentration and osmolality were higher ($P < 0.02$) in cattle fed the LF compared to the HF diet. Additionally, feeding LF resulted in a longer ($P = 0.02$) duration (h/d) and a larger ($P = 0.05$) area (PH × h/d) that pH was below 5.5. Although there was no diet effect on total and chloride competitive absorption (mmol/h and %/h) of SCFA, eating salivation (mL/min) was lower ($P = 0.02$), whereas resting salivation (mL/min) tended to be lower ($P = 0.10$) in cattle fed a LF diet. The lower ruminal pH in cattle fed the LF compared to the HF diet could be attributed to the increase in SCFA production and decrease in salivation, which were not compensated for by an increase in SCFA absorption.

Key Words: dietary forage content, saliva production, short-chain fatty acid absorption

Table 1567. Forage and total intake, ruminal parameters, microbial synthesis and nitrogen retention

	Energy Source		%of BW		P value			
	Corn	Citrus Pulp	0.3	0.6	ES	S	ES*S	SEM
Total DMI, %BW	1.77	1.76	1.74	1.78	ns	ns	ns	0.27
Forage DMI, %BW	1.32	1.31	1.44	1.18	ns	*	ns	0.26
Digestible DMI, %BW	1.19	1.18	1.08	1.29	ns	**	ns	0.16
Forage digestibility, %	58.00	58.08	57.88	58.2	ns	ns	ns	0.94
pH	6.46[a]	6.38[b]	6.47[a]	6.37[b]	*	*	*	0.09
NH3,mg/dL	6.12	5.96	6.65[a]	5.43[b]	ns	*	ns	0.85
Microbial synthesis, g/d	537.88	511.18	460.87	588.19	ns	*	ns	67.39
Nitrogen retention, % N % intake	29.74	21.88	16.58	35.04	ns	**	ns	5.18

SEM = Standard error of the mean, * = significant, ns = not significant, ES = energy source, S = supplementation.

1567 (M281) Interactions between levels and source of energy supplementation in beef cattle.

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The objective of this trial was to evaluate the effect of two levels and two sources of energy on voluntary intake and ruminal parameters of Nellore steers grazing intensively managed tropical pasture during the rainy season. Treatments corresponded to two levels of supplementation (0.3 and 0.6% of BW, as fed) combined with two sources of energy concentrate (fine ground corn and pelleted citrus pulp). Eight 24-mo-old rumen-cannulated steers (356 kg BW ± 9.8) were assigned to two 4 × 4 Latin squares and allocated in 2 ha of *Brachiaria brizantha cv.* Marandu (palisadegrass), managed in a rotational grazing system. Chromium oxide was used as an indigestible marker. Concentration of purine derivatives in the urine was used to estimate microbial synthesis. Total DMI was not affected by treatments. Feeding 0.6% of BW of energy supplement decreased forage intake ($P < 0.05$) and increased ($P < 0.01$) digestible DMI. There was interaction ($P < 0.05$) for ruminal pH between source and level of supplementation, with lower pH for steers fed citrus pulp and for steers supplemented at 0.6% of BW. Energy supplementation at 0.6% BW decreased ruminal N-NH_3 ($P < 0.05$) due to greater microbial synthesis ($P < 0.05$), resulting in greater N retention. No differences between ground corn and citrus pulp were observed as an energy supplement for growth cattle. Feeding 0.6% BW of energy supplement is an effective to increase digestible dry matter intake in grazing cattle.

Key Words: energy source, forage intake, supplementation

1568 (M282) Digestibility and nitrogen efficiency of growing beef cattle fed diets containing different proportions of *Stylosanthes* Campo Grande and corn silages.

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The objectives of this study were to evaluate total, ruminal and intestinal digestibility of nutrients, ruminal pH, ruminal ammonia concentration and nitrogen efficiency in growing beef cattle fed diets with varying proportions of *Stylosanthes* Campo Grande silage (SSt) replacing corn silage (CS). Treatments consisted of diets with ratios of 0:100, 25:75, 50:50, 75:25 and 100:0% SSt:CS. Diets consisted of 50% silage and 50% concentrate, formulated to be isonitrogenous (12.5% CP, DM basis). Ten crossbred Holstein-Zebu bulls with an average initial weight of 272 ± 86 kg, distributed in two 5 × 5 Latin squares were used. The bulls were non-castrated and rumen and abomasum-fistulated. This trial lasted 90 d divided in five experimental periods. Each period lasted 18 d and was divided into 10 d for adaptation to the diets and 8 d to collect samples. Chromium oxide (Cr_2O_3) was used to determine the fecal excretion and abomasum flow of nutrients. All data were analyzed using the PROC MIXED in SAS (version 9.1). Rumen apparent digestibility of CP and the intestinal apparent digestibility of NFC increased linearly ($P < 0.05$), with the addition of SSt to the diet. Intestinal digestibility of DM showed a quadratic effect ($P < 0.05$). Nitrogen balance, urea excretion in urine and urea nitrogen in the blood plasma showed no effect in response ($P > 0.05$) to the inclusion of SSt in the diet. Ruminal pH values were not affected ($P > 0.05$) by proportion of SSt in the diet ($P > 0.05$), but ruminal pH was affected ($P < 0.05$) by the time of collection, for which a cubic model was fit to the data. There was an interaction effect ($P < 0.05$) between treatment and collection time for rumen ammonia nitrogen concentration. Based on the results obtained in this study, it

can be concluded that *Stylosanthes* Campo Grande silage can be used as a source of roughage in the diet of beef cattle during the growing phase at a proportion of 50% of dry matter in the total diet. *Sponsored by FAPEMIG, CNPq and INCT-CA*.

Key Words: ammonia nitrogen, legume silage, ruminal pH

1569 (M283) Influence of *Macleaya cordata* preparation on feedlot performance and carcass characteristics of finishing bulls. R. Barajas*[1], B. J. Cervantes[2], I. Rogge[3], A. Camacho[1], and L. R. Flores[1], *[1]FMVZ-Universidad Autónoma de Sinaloa, Culiacan, México, [2]Ganadera los Migueles, S.A. de C.V., Culiacan, México, [3]Phytobiotics Futterzusatzstoffe GmbH, Eltville, Germany.*

The *Macleaya cordata* is a plant of the *Papaveraceae* family that contains as active components alkaloids of the Benzo[c] Phenanthridine family sanguinarine and chelerythrine; and alkaloids of the protopin family as is protopine and allocryptopine. Their combined effects include mild antimicrobial activity, anti-inflammatory properties, and inhibition of amino acids degradation; those characteristics suggest that *Macleaya cordata* could modify rumen microbial activity and reflect it on feedlot cattle performance. Despite *Macleaya cordata* is used in Europe as feed additive for farm animals, its effects of on feedlot cattle performance are not well-documented. In this research, 80 bulls weighing 380 ± SE 2.41 kg (approximately 75% *Bos taurus* and 25% *Bos indicus* blood), were used in a 91-d feedlot experiment to evaluate the influence of *Macleaya cordata* preparation on feedlot performance and carcass characteristics of finishing bulls. Blocked by initial weight, in a complete randomized block design with a 2 × 2 factorial arrangement, bulls were assigned to treatments as follows: 1) A 89% concentrate corn-cotton seed meal finishing diet (Control); 2) Control plus daily 4 g of *Macleaya cordata* preparation delivering 20 mg of alkaloids (MC); 3) Control plus 40 mg of sodium monensin/kg of DM (MN); and 4) Control plus MC and MN (MM). Results were analyzed for ANOVA as a complete randomized block design with a factorial 2 × 2 arrangement. MC was offered as Sangrovit-RS (Phytobiotics, Germany) a standardized preparation of *Macleaya cordata*; and monensin was supplied as Rumensin 200 (Elanco Animal Health, IN). Zilpaterol hydrochloride (Zilmax; Merck Animal Health) was supplemented during latest finishing. Treatments had no effect ($P > 0.15$) on final weight, ADG, DMI, and hot carcass weight. The inclusion of *Macleaya cordata* tended to increase ($P = 0.10$) diet net energy for maintenance and gain (2.04 *vs.* 1.98 Mcal ENm/kg; and 1.38 *vs*. 1.33 Mcal ENg/kg). Supplementation with *Macleaya cordata* tended ($P = 0.09$) to improve DMI/hot carcass gain ratio (7.946 vs. 8.452 kg DMI/kg of carcass). The addition of MC tended ($P = 0.08$) to reduce KPH-fat (1.96 *vs.* 2.13%). Remainder carcass characteristics were not affected by treatments ($P > 0.15$). It is concluded that the supplementation of *Macleaya cordata* preparation may contribute to improve diet net energy use, feed carcass conversion, and decreases the amount of fat deposited around of kidney, pelvis and heart in finishing bulls.

Key Words: beef cattle, *Macleaya cordata*, sanguinarine

1570 (M284) Supply levels of multiple supplements for beef heifers on pasture during the dry season: ruminal pH and ammonia nitrogen. R. P. D. Silva*, J. T. Zervoudakis, L. K. Hatamoto-Zervoudakis, L. D. S. Cabral, A. J. Neto, J. Q. Soares, A. C. B. Melo, E. R. Donida, P. I. José, R. C. Soares, E. A. Teixeira, and A. J. Possamai, *Federal University of Mato Grosso, Cuiaba, Brazil.*

This research aimed to evaluate the effect of different levels of multiple supplements for beef heifers that were restricted grazing during the dry season on pH and ruminal ammonia nitrogen. Five Nellore heifers were used, with age and initial weights average of 20 mo and 344.0 kg, respectively. The pastures were divided into five paddocks of 0.25 ha each, consisting of *Brachiaria brizantha* cv. Marandu. The experiment was divided into 5 × 5 Latin square design, composed by five experimental periods of 20 d each and five animals. The strategy adopted was to provide multiple supplements (soybean hulls + ground corn grain + soybean meal + sunflower + urea and mineral mix) at levels of 2, 4, 6, and 8 kg/animal/d. The animals were fed in two fixed hours: 50% of the daily amount at 1000 h and 50% at 1500 h, the mineral mixture was offered ad libitum (control). For determination of pH and ammonia concentration in the rumen fluid samples were collected by gavage on the 19 and 20 d of each period, 2 h before supplementation (10 to 0 h time) and 2 h after supplementation of afternoon (15 to 2h time).The availability of total dry matter was 2.29 ton/ha. The strategies of supplementation promoted a reduction of ruminal pH ($P = 0.0343$) and increased the concentration of ruminal ammonia nitrogen (NH_3–N) ($P = 0.0004$) before providing supplements, and after the supplementation the NH3 expressed a quadratic effect ($P = 0.0023$). The values observed for ruminal pH varied from 6.44 to 6.78 before supplementation in the morning and from 6.43 to 6.79 two h after feeding the animals in the afternoon, not harming the ruminal microbiota. Providing high levels of multiple supplements increases the nutritional support for cattle on systems with low level and quality of pasture during the dry season.

Key Words: *Brachiaria brizantha*, replacement effect, rumen

1571 (M285) Comparison of commercially available lick tubs to daily by-product supplementation of calves grazing corn residue. M. Jones*, M. Jones, J.C. MacDonald, T.J. Klopfenstein, G.E. Erickson, A.K. Watson, *University of Nebraska–Lincoln, Lincoln.*

Corn residue is a forage source low in energy and crude protein to meet the needs of growing calves. Providing supplementation increases average daily gain of calves grazing corn residue. The objective of this trial was to compare the use of a commercially available lick tub to daily by-product supplementation of calves grazing corn residue. One hundred twenty five crossbred steers (240 kg ± 2.64) were backgrounded on irrigated corn residue for a 60-d grazing period at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, NE. The trial was replicated over two consecutive years (n = 8). Each year, an irrigated corn residue field was divided into eight paddocks, with four replications receiving dried distillers grains (DGS) and four having continuous access to lick tubs. Calves on the DGS treatment received supplementation in a bunk at 1.36 kg/head per d. Stocking rate was calculated based on grain yield of the field at harvest multiplied by an estimated 3.64 kg forage consumed/bu, 85% grazing efficiency factor and number of hectares available for grazing. Data was analyzed using Proc Glimmix with year run as a random effect. Average daily gain (ADG) of steers receiving dried DGS was 0.62 kg/head per day in comparison to 0.38 kg/head per day for steers on the lick tub treatment ($P < 0.01$). Average supplement intake for cattle on the lick tub treatment was 0.76 kg/day on an OM basis compared to 1.28 kg/day for steers receiving dried DGS ($P < 0.01$). Since forage estimations were not taken, supplement efficiency was used to compare the change in gain to intake by dividing ADG by supplement intake. Supplement efficiency for the lick tubs and dried DGS treatments were 43 and 46% on a DM basis ($P < 0.01$) compared to 50 and 48% on an OM basis, respectively ($P = 0.64$). Lick tubs are a convenient method for providing supplementation to calves and on an OM basis, offer similar supplement efficiency when compared with daily by-product supplementation.

Key Words: corn residue, grazing, stocker cattle, supplementation

1572 (M286) Dry matter intake of supplemented cattle under grazing during the dry season. T. O. J. A. Lins*, R. R. Silva, F. B. Mendes, M. M. Lisboa, M. M. S. Pereira, G. Abreu Filho, S. O. Souza, and L. G. Silva, *Universidade Estadual do Sudoeste da Bahia, Itapetinga, Brazil.*

This study aimed to evaluate the dry matter daily intake of cattle supplemented on pasture during dry season. The experiment was conducted in southwest region of the state of Bahia, Brazil. The study was the growing phase of 36 crossbred steers (*Bos taurus* x *Bos indicus*) with initial body weight of 378 kg ± 7.5kg and median age of 14 mo. The animals were distributed in a completely randomized design, with four treatments and eight replicates and were managed in an experimental area formed by a *Brachiaria brizantha* cv. Marandu in a system of intermittent grazing. The supplement was formulated so that the same amount of crude protein (CP%) coming from the supplement was consumed daily by animals in the different treatments. Thus, the treatments were on basis of body weight of animals (% BW): T2, 0.2%BW with 50% CP, T4,0.4%BW with 25% CP; T6, 0.6%BW with16.67% CP, and T8, 0.8%BW with 12.5% CP. The statistical model used was: $Y_{ijk} = \mu + T_i + e_{ijk}$, where: Y_{ijk}- observed value; μ- overall constant; T_i- effect of treatment i and e_{ijk}– randomized error. There was no difference in the daily intake of total dry matter (tDMI) ($P > 0.05$) between treatments. There was a linear effect ($P < 0.05$) in dry matter intake of forage (fDMI), characterizing a substitutive effect. It is concluded that supplementation of steers in growing phase presents better results when used at low levels, although with a high protein content.

Key Words: weight gain, protein supplementation, continuous stocking, substitutive effect

Table 1572. Dry matter intake of supplemented cattle under grazing during the dry season and their respective regression equations and coefficients of determination (R2)

Varibles	Treatment (%BW) 0.2%	0.4%	0.6%	0.8%	Regression equations	R2
tDMI (kg.day-1)	7.41	7.81	8.18	8.09	–	–
fDMI (kg.day-1)	6.63	6.24	5.79	4.96	Y = 7.27025-2.73324X	0.96

1573 (M287) Interaction between grazing management and energy supplementation on behavior of grazing beef cattle. L. R. Dell Agostinho Neto*[1], M. G. M. F. D. Santos[1], M. R. Lovaglio[2], D. F. A. Costa[2], J. R. R. Dórea[2], and F. A. P. Santos[2], [1]*University of Sao Paulo, Piracicaba, Brazil,* [2]*University of São Paulo, Piracicaba, Brazil.*

The objective of this study was to evaluate the effects of two grazing managements, based on canopy height, and two levels of energy supplementation on ingestive behavior of beef cattle grazing an intensively managed tropical grass. Treatments were two pre-grazing heights (25 cm and 35 cm) both managed with stubble height corresponding to 60% of the pre-grazing height (15 cm and 21 cm, respectively) combined with two levels of energy supplementation (0 and 0.6% BW of fine ground corn). Eight 36-mo-old cannulated Nellore steers (487 kg BW ± 6.96 kg) were assigned to two 4 × 4 Latin squares and allocated in 2 ha of *Brachiaria brizantha* pasture. Animals were monitored every 5 min during 24 h to evaluate the ingestive behavior, according to the activities: grazing, rumination and idle. Bite

Table 1573. Grazing time, rumination, idle and bite rate of beef cattle grazing tropical grass

	Management, cm		Supplementation, % of BW		P value			
Activities	25- 15	35- 21	0	0,6	M	S	M*S	SEM
Grazing[1]	292.19	295.94	330.31	257.81	0.8652	0.0032	0.9323	42.9
Rumination[1]	322.5	349.37	350	321.87	0.2497	0.2290	0.9350	42.2
Idle[1]	735.31	704.69	669.69	770.31	0.4379	0.0168	0.9238	73.52
Bite rate[2]	28.79	29.02	28.05	29.76	0.8968	0.3535	0.3962	2.49

[1] Minutes.
[2] Bite/minute

rate was also evaluated. Grazing time was not affected by the managements ($P > 0.05$), however decreased ($P < 0.05$) with the energy supplementation (72.5 min). Both, management and supplementation did not affect rumination and bite rate ($P > 0.05$). Time spent in idle was increased ($P < 0.05$) by energy supplementation (100.62 min). The managements based on 60% of the pre-grazing height did not affect DMI.

Key Words: supplementation, beef cattle, Marandu palisadegrass, ingestive behavior

1574 (M288) Supply levels of multiple supplements for beef heifers on pasture during the dry season: Intake and digestibility of nutrients. R. P. D. Silva*[1], J. T. Zervoudakis[1], L. K. Hatamoto-Zervoudakis[1], L. D. S. Cabral[1], E. Alexandrino[2], R. L. Galati[3], J. Q. Soares[1], A. C. B. Melo[1], E. R. Donida[1], P. I. José[1], A. J. Possamai[1], K. F. Cervelati[1], L. B. D. Freiria[1], and D. A. D. Faria[1], *[1]Federal University of Mato Grosso, Cuiaba, Brazil, [2]Federal University of Tocantins, Araguaína, Brazil, [3]Federal University of Mato Grosso, Cuiaba, Brazil.*

This research aimed to evaluate the effect of levels of multiple supplements for beef heifers that were restricted grazing during the dry season on intake and digestibility of nutrients. Five Nellore heifers were used, with age and initial weights average of 20 mo and 344.0 kg, respectively. The pastures were divided into five paddocks of 0.25 ha each, consisting of *Brachiaria brizantha* cv. Marandu. The experiment was divided into 5 × 5 Latin square design, composed by five experimental periods of 20 d each and five animals. The strategy adopted was to provide multiple supplements (soybean hulls + ground corn grain + soybean meal + sunflower + urea and mineral mix) at levels of 2, 4, 6, and 8 kg/animal/d. The animals were fed in two fixed hours: 50% of the daily amount at 1000 h and 50% at 1500 h, the mineral mixture was offered ad libitum (control). To estimate feed intake, chromium oxide was used as an external marker and indigestible NDF was used as an internal marker. The feces collections were made in 3 d in different collection times. The availability of total dry was 2.29 ton/ha. The intake dry matter, organic matter, crude protein (CP), non-fiber carbohydrates (NFC) and total digestible nutrients, and total apparent digestibility of dry matter, crude protein, total carbohydrates and NFC increased linearly ($P < 0.0001$) and the dry matter intake of forage decreased ($P < 0.0001$) with supplementation levels, it indicates that there was replacement effect. We conclude that providing supplement for grazing cattle in the dry season enhances the digestion of nutrients from forage.

Key Words: *Brachiaria brizantha*, replacement effect, nutrients intake

1575 (M289) Individual and additive value of conventional and non-conventional technologies in beef heifers housed and fed using a GrowSafe feeding system. A. R. Harding*[1], G. K. Jim[2], C. W. Booker[2], E. J. Behlke[2], S. L. Parr[2], S. J. Hannon[2], T. M. Greer[2], Z. D. Paddock[2], M. L. May[2], L. O. Burciaga-Robles[2], and C. R. Krehbiel[1], *[1]Oklahoma State University, [2]Feedlot Health Management Services, Ltd., Okotoks, AB, Canada.*

This study evaluated the effects of conventional and non-conventional production (NCP) technologies in feedlot cattle. A total of 384 yearling heifers (859 ± 77 lb.) were stratified by BW and randomly allocated to 1 of 8 treatments: NCP1: fibrolytic feed enzyme (Econase RDE; Sage Biosciences Inc., Edmonton, Alberta); NCP2: Oleobiotec Ruminant (Oleo; Laboratoires Phodé, Terssac, France); NCP3: CitriStim (ADM Alliance Nutrition Inc., Quincy, Illinois); NCP4: Oleo and CitriStim. All NCP systems received a non-medicated supplement. Blended production systems (BP) included: BP1: non -medicated supplement, Oleo, melengesterol acetate (MGA; Zoetis Canada, Kirkland, Québec), and Zilpaterol hydrochloride (Zilmax; Merck Animal Health, Intervet Canada Corp., Kirkland, Québec) for the last 20 d; BP2: medicated supplement containing Rumensin and Tylan (Elanco Animal Health, Guelph, Ontario), MGA, Oleo, and Zilmax for the last 20 d. Control groups included a negative control (NEG): non-medicated supplement; and conventional production (CP): medicated supplement containing Rumensin, Tylan, and MGA, and Zilmax for the last 20 d. Individuals were randomized within diet treatment to receive an implant (Revalor-200; Merck Animal Health), parasite control (Dectomax Pour-On Solution; Zoetis Canada), both, or neither. Heifers were fed for 123 d and DMI was recorded using GrowSafe feeding systems (GrowSafe Systems Ltd., Airdrie, Alberta). Data

were analyzed using the GLIMMIX procedure (SAS Institute Inc, Cary, North Carolina). Relative to the NEG group, BP2 and CP treatments had greater live and carcass adjusted ADG and improved live G:F ($P < 0.05$) and the BP1, BP2, and CP treatments had improved carcass adjusted G:F ($P < 0.001$). No differences ($P > 0.05$) were detected in carcass characteristics of NCP and BP groups compared to the NEG and CP groups. Implanted cattle had greater ADG and improved G:F vs. non-implanted cattle ($P < 0.001$) while no differences ($P > 0.05$) in feedlot performance or carcass characteristics were detected for parasiticide treatment. No interactions ($P > 0.05$) were identified between diet, implant status and/or parasiticide. These results indicate that conventional production systems improve beef heifer performance.

Key Words: feedlot, cattle, technology

1576 (M290) Effect of pregnancy and feeding level on voluntary intake, digestion and microbial N production in Nellore cows. M. P. Gionbelli*[1,2], M. S. Duarte[2], S. C. Valadares Filho[1,2], E. Detmann[1,2], B. C. Silva[2], D. F. Sathler[2], T. R. Gionbelli[2], F. A. Villadiego[2], and L. H. Silva[2], *[1]Instituto Nacional de Ciência e Tecnologia–Ciência Animal, Viçosa, Minas Gerais, Brazil, [2]Universidade Federal de Viçosa, Minas Gerais, Brazil.*

The objective of this experiment was to evaluate the effects of pregnancy and feeding level on intake, digestibility and efficiency of microbial N production in Nellore cows. Forty-four multiparous Nellore cows (32 pregnant and 12 non-pregnant) with average initial body weight of 451 ± 10 kg were fed either HIGH (ad libitum) or LOW (restricted feeding 1.2 times maintenance according to the NRC) feeding level. The diet consisted of corn silage (85%), ground corn, soybean meal, urea and mineral mixture. The intake was controlled daily and the DMI was evaluated weekly. In vivo apparent total digestibility was estimated using indigestible NDF as an internal marker and microbial N synthesis was estimated using the technique of purine derivatives in urine. Fecal and urine samples were collected every 28 d. The voluntary feed intake reduced as the pregnancy advances in Nellore cows and can be calculated as DMI (kg/d) = (16– 0.0093 × days of pregnancy)/1000 × SBW, where SBW is shrunk body weight. The average DMI of LOW-fed cows corresponded to 102, 98, and 67% of the amount of energy necessary to attend the maintenance and pregnancy energy requirements suggested by NRC for a cow at 0, 135, and 270 d of pregnancy, respectively. However, LOW-fed cows had 0.26 kg/d of average shrunk body gain indicating that the nutrient energy requirements of Zebu cows are likely lower than those suggested by NRC. The interaction between the feeding level and days of pregnancy was significant ($P < 0.05$) for the digestibility of DM, OM, CP, ether extract (EE), NDF corrected for ash and protein (NDF_{ap}) and GE, and the values of TDN. In all these cases there was a reduction in digestibility with increasing gestation age in HIGH-fed cows, while digestibility of OM, CP, EE, NDF_{ap} and GE increased as function of days of pregnancy in LOW-fed cows. The reduction in the digestibility of neutral detergent fiber occurs faster than in dry matter digestibility. These data suggests that the reduction of the digestibility as pregnancy increases in ad libitum fed cows is caused by an increase in the rate of passage as compensation factor for the ruminal volume reduction. There were no direct effects of pregnancy on microbial N production in Nellore cows. *Funded by INCT-CA, CAPES, CNPq, and FAPEMIG.*

Key Words: beef cattle, *Bos indicus*, dry matter intake, gestation, total digestible nutrients, Zebu

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1577 (M291) Growth and feed intake of Nellore steers fed whole corn diets containing feed antibiotics. B. J. M. Lemos[1], F. G. F. Castro[2], B. P. C. Mendonça[2], A. L. Braga Netto[2], C. E. Dambros[1], D. B. Fernandes[2], V. R. M. Couto[1], and J. J. R. Fernandes*[1], *[1]Universidade Federal de Goiás, Goiânia, Brazil, [2]AgroCria, Goiânia, Brazil.*

The objective was to investigate the effects of feed antibiotics on growth and feed intake of feedlot steers fed whole corn diets. Ninety-eight Nellore steers (302 ± 47 kg of BW and 24 mo of age) were assigned to a randomized complete block design experiment with four blocks (based on initial BW) and five treatments (Mon30: monensin 30 ppm; Virg25: virginiamycin 25 ppm; Mon20+Virg25: monensin 20 ppm + virginiamycin 25 ppm; Fla40: flavomycin 40 ppm; Mon20+Fla20: monensin 20 ppm + flavomycin 20 ppm). Pen was the experimental unit. The experiment consisted of a 100-d period. All steers were fed ad libitum with TMR (88.2% DM, 12.5% CP, 71.5% TDN) with 85% whole grain corn and 15% pelleted protein concentrate on a DM basis. Animals were weighed after a 16-h fast on d 0 and 100 of the experimental period to determine the ADG and feed efficiency (G:F, g of BW gain/kg of feed). No effect ($P > 0.01$) was observed on growth and feed intake of Nellore steers fed whole corn diets containing feed antibiotics (Table 1577). Feed antibiotics tested had the same results. Feed antibiotics tested were able to maintain satisfactory performance in finishing beef cattle fed high-concentrate diets based on whole corn.

Key Words: beef cattle, performance, whole corn diet

Table 1577. Initial body weight (BWi), final body weight (BWf), dry matter intake (DMI) daily (kg/d) and DMI as % of BW, average daily gain (ADG) and feed efficiency (G:F) of Nellore steers fed whole corn diets containing feed antibiotics

	Feed antibiotics						
Variables	Mon30	Virg25	Mon20+ Virg25	Fla40	Mon20+ Fla20	SEM	*P*-Value
No. of pens (steers)	4 (20)	4 (20)	4 (19)	4 (19)	4 (20)	–	–
BWi (kg)	393	387	392	393	393	3.49	0.755
BWf (kg)	539	534	537	544	539	4.38	0.618
DMI							
kg/d	8.4	9.0	8.8	9.3	9.1	0.39	0.578
% of BW	1.8	1.9	1.9	2.0	2.0	0.08	0.731
ADG (kg/d)	1.465	1.466	1.444	1.504	1.463	0.04	0.902
G:F	0.18	0.17	0.17	0.16	0.16	0.01	0.799

1578 (M292) Effects of volume weight, precision processing and processing index on in vitro ruminal fermentation of dry-rolled barley grain. U. Y. Anele*[1], B. Refat[1], M. L. Swift[2], Z. He[1], T. A. McAllister[1], and W. Yang[1], *[1]Lethbridge Research Centre, Agriculture and Agri-Food Canada, AB, [2]Alberta Agriculture and Rural Development, Lethbridge, Canada.*

A study using batch culture technique was conducted to evaluate the effects of volume weight (VW, g/L), precision processing (PP; sieving grains into large versus small kernels and rolling based on kernel size), and processing index (PI; VW after rolling/VW before rolling × 100%) on kinetics of gas production, dry matter degradability (DMD), molar proportions and total short chain fatty acids (SCFA) of dry rolled barley grain. The study was arranged in a 2 × 2 × 2 factorial design. Gas production and DMD were measured at 3, 6, 12, and 24 h of incubation using rumen fluid from three fistulated beef heifers fed 70% barley silage and 30% barley grain. We hypothesized that incorporating other factors with PI would help improve prediction of the feeding value of processed barley grain. Barley samples were collected monthly from 10 different feedlots in Southern Alberta for 1 yr. Samples were ranked according to their VW into low (< 600 g/L) and high (> 600 g/L), which were later subjected to PP (processed vs. control) before dry-rolled with extent of processing expressed as PI 75 or 85% ± 3. The dry-rolled samples used in the study were not subjected to further grinding. Precision processing x PI interactions ($P < 0.01$) were observed for asymptotic cumulative gas volume, rate, lag time and absolute initial gas produced during the first hour. In addition, a PP × VW interaction ($P < 0.05$) was noted for cumulative gas volume. There were strong interactions ($P < 0.01$) between PP, VW and PI for the b fraction (insoluble but degradable in the rumen) and effective degradability of the samples. Effective degradability coefficients ranged from 0.18 to 0.26. Greater degradability coefficients were noted for processed samples with lower PI. Only PI had an effect ($P < 0.05$) on the rate of DMD. Interactions ($P < 0.05$) between PP, VW and PI were noted for the isobutyric, butyric, isovaleric, valeric and caproic contents of the samples after 6 h of incubation. Total SCFA values ranged from 30.2 to 40.1 mmol/L. Apart from PP and PI interaction ($P < 0.05$) on C_2:C_3, no other interaction was observed after 24 h of incubation. Regression results showed that VW and PP was better in predicting rate of DMD than PI and this is consistent with our hypothesis.

Key Words: barley, beef cattle, degradability, prediction

1579 (M293) Total tract NDF digestion predicted using rumen in vitro measures is related to commercial dairy in vivo total tract nutrient digestion. J. P. Goeser*[1,2], and C. R. Heuer[1,2], *[1]Dep. of Dairy Science, University of Wisconsin–Madison, Madison, [2]Rock River Laboratory, Inc, Watertown, WI.*

Dairy diet in vivo total tract digestion estimates of OM and NDF have been correlated to animal performance and used in the field to assess opportunities for improvement. Measuring in vivo digestion on commercial farms however is time consuming and relatively costly. Our objective was to determine if total tract NDF digestion estimates predicted from rumen in vitro data (TTNDFD) were related to in vivo apparent total tract organic matter (OM) and carbohydrate digestion coefficients. Commercial dairy total mixed ration (TMR) samples ($n = 50$) submitted for in vivo digestion analysis (% of nutrient, using 120h iNDF as an internal marker) were further digested in duplicate for 24, 30, and 48 h using Combs-Goeser rumen in vitro techniques. Potentially digestible NDF (pdNDF, % of NDF) was estimated using 120-h NDFD measures and NDF K_d was calculated using log-linear transformed 24, 30, and 48 h uNDF residues. TTNDFD was predicted by $K_d/(K_d+K_p)$ and a K_p based on NDF passage. In vivo organic matter and carbohydrate digestion coefficients (OMD, NDFD, pdNDFD and starchD) were also determined. TMR nutrient content and in vivo digestion coefficient descriptive statistics were calculated. TTNDFD estimates were regressed on in vivo OMD, NDFD, pdNDFD, and StarchD using SAS JMP Pro v11.0 and residuals assessed for normality. The TTNDFD was significantly ($P < 0.01$) related to OMD, NDFD, and pdNDFD. The regression equation parameters are outlined in Table 1579. These data suggest further evaluation is warranted but demonstrate a significant relationship between TTNDFD predictions and in vivo total tract digestion measures. On commercial dairies, in vitro TTNDFD measures may help identify dairy nutritive opportunities.

Key Words: total tract, NDF, digestion

Table 1579. TMR nutrient and digestion coefficient descriptive statistics and regression model parameters in relation to TTNDFD. Results followed by * or ** differ from zero ($P < 0.05$ and $P < 0.01$, respectively)

	OM	NDF	pdNDF	Starch
TMR Nutrient Content (% of DM)				
Mean	92.01	31.93	19.30	25.15
StDev	1.03	3.74	3.22	4.04
in vivo TMR Digestion Coefficient (% of Nutrient)				
Mean	58.82	37.80	61.88	94.73
StDev	9.45	11.14	14.62	4.66
Regression Model Parameters in Relation to TTNDFD				
Intercept	38.50**	1.09	24.98**	92.36*
Slope	0.56**	1.01**	1.01**	0.07
R2	0.14	0.30	0.18	0.01
RMSE	8.86	9.39	13.38	4.68

Table 1580.

Items	Control	Vet	Tom	± SE	Pro > F
Milk yield (Kg/day)	7.26^{b}	7.91^{a}	7.59^{ab}	0.095	0.007
4% FCM (kg/day)	10.36	11.56	10.93	0.071	0.061
Fat %	6.86	7.10	6.96	0.044	0.072
Total Protein %	3.88^{b}	4.02^{ab}	4.20^{a}	0.051	0.023
Casein %	2.87^{b}	3.14^{a}	3.30^{a}	0.058	0.001
Whey %	0.827	0.804	0.845	0.014	0.495
NPN %	0.037^{a}	0.035^{a}	0.028^{b}	0.001	0.033
True protein %	3.843^{b}	3.985^{ab}	4.172^{a}	0.065	0.031
Urea N. mg/g	28.14^{a}	20.80^{b}	21.00^{b}	0.965	0.000
Lactose %	4.66	4.73	4.68	0.029	0.871
Ash %	0.802	0.800	0.784	0.010	0.776
Total solids %	16.26	16.56	16.82	0.150	0.336
Solids not fat %	9.44	9.46	9.86	0.138	0.405
Total CLA (g/100g fat)	0.23	0.32	0.25	0.053	0.081

1580 (M294) Influence of fibrolytic enzyme supplements on production performance of lactating buffaloes in early lactation.

T. A. Morsy*, and S. Kholif, *National Research Center, Cairo, Egypt.*

The use of biotechnology such as exogenous fibrolytic enzymes to enhance quality and digestibility of fibrous forage is a novel approach for delivering practical benefits to ruminant production systems. A study was conducted to evaluate the use of commercial exogenous enzymes as feed additives with lactating buffaloes on milk yield and composition. Twenty-one lactating buffaloes in early lactation had body weight on average (570 ± 15 kg) were divided into three groups (seven animals each) using complete random design. Animals were fed individually on basic diet total mixed rations (TMR; 60% forage: 40% concentrate, dry matter basis). Treatments were 1) no additives (control), 2) 40 g Tomoko/head/day (Tom), and 3) 40 g Veta-Zyme Plus/head/day (Vet). Animals were milked twice daily and milk production was recorded at every milking. Milk samples were obtained every two wk from each buffalo at all milkings to determine milk composition. The enzyme additive did not alter dry matter intake, but Milk yield, 4% Fat Corrected Milk, and Fat percent significantly increased with (Vet) treatment than all other treatments. However, total protein percent increased ($P < 0.05$) with (Vet) and (Tom) treatments than control. Regarding the milk fatty acids profile, it was found that the total unsaturated fatty acids and conjugated linolenic acid (CLA) were increased ($P = 0.08$) with (Vet) and (Tom) groups compared with control. Therefore, the addition of an exogenous fibrolytic enzyme additive to the diet of lactating buffaloes affected milk production as well as milk quality.

Key Words: fibrolytic enzyme, lactating buffaloes, milk yield and composition

1581 (M295) Effect of two exogenous fibrolytic enzyme preparations on rumen fermentation and in situ degradability kinetics in dairy cattle.

J. J. Romero*[1], E. G. Macias[2], Z. Ma[1], R. M. Martins[3], C. R. Staples[1], and A. T. Adesogan[1], *[1]Dep. of Animal Sciences, University of Florida, Gainesville, [2]Dep. de Zootecnia, Universidad Nacional Agraria La Molina, Lima, Peru, [3]Dep. de Zootecnia, Universidade Federal de Viçosa, Minas Gerais, Brazil.*

The objective was to compare effects of two *Trichoderma reesei* exogenous fibrolytic enzyme preparations (EFE) on the ruminal degradation and fermentation of a bermudagrass- and corn silage-based TMR. Endoglucanase and xylanase activities of a moderate xylanase (MIX) and xylanase-rich (XYL) EFE were 2087 and 2714 and 10,549 and 26,926 µmol/min per g, respectively. Both EFE improved milk production by lactating dairy cows in previous studies. Three ruminally-cannulated lactating Holstein cows (735 ± 8 kg; 159 ± 47 DIM) were assigned to Control (CON), MIX or XYL treatments in a 3 × 3 Latin square design with 23-d periods. The MIX and XYL EFE were added to the ration of the cows just before feeding at rates of 3.4 and 1 mL/kg of TMR DM, respectively. On d 18 of adaptation, ground (4 mm) samples of the TMR were weighed (5 g of DM) into in situ bags, treated with or without the EFE, and massaged to ensure thorough mixing. Exactly 24 h later, bags were placed in the rumens of the cows for 0, 4, 8, 16, 24, 48, and 72 h. All bags were removed simultaneously, washed, dried, and weighed. An exponential model was fitted to the DM degradation data. On d 23, ruminal fluid was collected from each cow just before feeding and every 2 h afterward for 10 h and analyzed for fermentation products and pH. The model used to analyze the fermentation data included effects of treatment, time, treatment by time interaction, period and the random effect of cow. A similar model without the time effect was used to analyze the in situ degradability data. Applying EFE had no effect ($P > 0.1$) on in situ degrad-

ability lag phase, washout fraction, potentially degradable fraction, undegradable fraction, or fractional degradation rate of DM. Also, EFE application did not affect ($P > 0.1$) ruminal pH or concentrations of ammonia-N, total VFA, acetate (A), propionate (P), butyrate, isobutyrate, isovalerate, valerate or the A:P ratio. Adding these EFE to a bermudagrass and corn silage- based TMR did not affect ruminal fermentation or in situ ruminal degradability under the conditions of this study.

Key Words: dairy cattle, enzyme, rumen kinetics

1582 (M296) Proteomic analysis of compositional differences between exogenous fibrolytic enzyme preparations that were effective or ineffective at improving forage digestibility. J. J. Romero*[1], Z. Ma[1], C. Silva-Sanchez[2], and A. T. Adesogan[1], [1]*Dep. of Animal Sciences, University of Florida, Gainesville,* [2]*Proteomics, ICBR, University of Florida, Gainesville.*

The objective was to use novel proteomic tools to identify differences in proportions of key enzymes and auxiliary proteins involved in hemicellulose and lignocellulose degradation between effective and ineffective exogenous fibrolytic enzyme preparations (EFE). We recently examined effects of applying 12 EFE from three companies on in vitro NDF digestibility (NDFD) of bermudagrass haylage (BH). The most- (2A) and second most- (11C) effective EFE were from *Trichoderma reesei* and they increased the NDFD of BH from 35.6 (Control) to 40.4 and 40.0%, respectively. The least effective EFE (9C) was from *T. reesei* and *Aspergillus* spp. and the NDFD of BH treated with this EFE was 36.2% (SEM = 0.55). The relative ratios of proteins in either 11C to 2A or 9C to 2A were analyzed in triplicate using quantitative proteomics. Specifically, EFE were analyzed with isobaric tags for relative and absolute quantitation coupled with liquid chromatography-mass spectrometry (iTRAQ LC-MS/MS). The identification and analysis of proteins were performed using ProteinPilot software version 4.5. Proteins were identified using the National Center for Biotechnology Information database for *T. reesei* and *Aspergillus* spp. The unused score threshold was set to > 1.3 (equivalent to 95% confidence or better). The Student's *t* test was used to measure the significance of the relative ratio of the proteins. The degrees of freedom were the number of distinct peptides within the protein evaluated minus 1. Quantitation was based on at least three unique peptides for each protein. The 2A EFE had 10 times more endoglucanase III, 17 times more acetylxylan esterase with Cellulose Binding Module 1, 33 times more xylanase III, 25 times more β-xylosidase, 7.69 times more polysaccharide monooxygenase with Cellulose Binding Module 1, and 3 times more swollenin compared to 9C. Relative to 11C, 2A had 14.3 times more xylanase III, 14.3 times more β-xylosidase, 7.7 times more endoglucanase III, and 1.9 times more polysaccharide monooxygenase. Therefore, the efficacy of the EFE at increasing NDFD was reflected by the relative proportions of novel xylanolytic and cellulolytic enzymes and auxiliary proteins that they contained.

Key Words: proteomics, enzyme, digestibility

1583 (M297) Effects of ensiling, exogenous protease addition and inoculation on ruminal in vitro starch digestibility in rehydrated corn. L. F. Ferraretto*, S. M. Fredin, R. D. Shaver, and P. C. Hoffman, *University of Wisconsin, Madison.*

Three experiments were simultaneously performed to evaluate the impact of: 1) rehydration and ensiling of dry ground corn on starch digestibility; 2) exogenous protease addition to rehydrated unensiled and ensiled corn on starch digestibility; and 3) exogenous protease addition or inoculation on fermentation profile and starch digestibility of rehydrated ensiled corn. To achieve these objectives, seven treatments ($n = 3$) were performed: dry ground corn (DRY), DRY + water addition to achieve DM content of 70% (WAT), WAT + exogenous protease addition (WATP), WAT ensiled for 30 d (ENS), WATP ensiled for 30 d (ENSP), ENS + inoculation (ENSI) and ENSP + inoculation (ENSPI). Vacuum-sealed bags were used for ensiled treatments. Exogenous protease (DSM Nutritional Products, Basel, Switzerland/Novozymes, Bagsvaerd, Denmark) was added at a rate of 1825 mg of protease per kg of corn DM. The recommended dose (4.5 g per ton of rehydrated corn) of a microbial inoculant containing lactic acid bacteria (1×10^9 CFU/g; Silo Charger "D", NU-AG Bosko, Inc., Oskaloosa, IA) was applied to inoculant treatments. Experiment 1 compared DRY, WAT and ENS in a completely randomized designed. Data were analyzed using Proc Mixed of SAS with treatment as a Fixed effect. Experiment 2 compared WAT and ENS without or with exogenous protease addition (WATP and ENSP, respectively) in a completely randomized designed in a 2×2 factorial arrangements of treatments. Data were analyzed using Proc Mixed of SAS with ensiling, protease addition and their interaction as Fixed effects. Experiment 3 compared the effects of exogenous protease addition and inoculation in ENS corn (ENS, ENSP, ENSI, and ENSPI). In experiment 1, starch digestibility was greater for ENS (64.9%) than DRY and WAT (51.7% on average). In experiment 2, ensiling and exogenous protease addition increased ($P < 0.05$) starch digestibility, but exogenous protease addition was more effective in ENS than WAT (6.4 vs. 2.6% units increase). In experiment 3, starch digestibility was increased by the addition of protease ($P = 0.02$) but not inoculant ($P = 0.38$). Inoculation resulted in lower ($P < 0.05$) pH, acetate, propionate and ethanol concentrations, but greater lactate ($P = 0.001$) and total acid ($P = 0.09$) concentrations. Ensiling and protease addition increased starch digestibility in rehydrated corn.

Key Words: ensiling, protease, starch digestibility

1584 (M298) Forage type and exogenous fibrolytic enzyme application rate effects on the digestibility of dairy cattle forages. J. J. Romero[1], Z. Ma[*1], E. G. Macias[2], D. H. Garbuio[3], and A. T. Adesogan[1], *[1]Dep. of Animal Sciences, University of Florida, Gainesville, [2]Dep. de Zootecnia, Universidad Nacional Agraria La Molina, Lima, Peru, [3]Universidade Estadual Paulista, São Paulo, Brazil.*

The objective was to examine the effects of applying two *Trichoderma reesei* exogenous fibrolytic enzyme products (EFE) at different application rates on the in vitro DM (DMD) and NDF (NDFD) digestibility of bermudagrass silage, a 50:50 alfalfa-orchardgrass hay mixture and corn silage. Treatments were a Xylanase-rich EFE (XYL), a 25:75 mixture of XYL and a cellulase EFE (MIX), and an untreated Control. Endoglucanase and xylanase activities of MIX and XYL were 2087 and 2714 and 10,549 and 26,926 μmol/min per g, respectively. The EFE were diluted in water and applied in quadruplicate to the substrate at 0, 0.5, 1, 4, and 8 μL of EFE/g of DM. The suspensions were incubated at 25°C for 24 h before addition of buffered-rumen fluid (39°C) and further incubation for 24 h in two runs. Rumen fluid was obtained from three lactating dairy cows fed TMR containing all of the tested forages. Data were analyzed as a completely randomized design with a 2 × 5 × 3 factorial treatment arrangement. The optimal dose was defined as the application rate with the highest digestibility that was higher ($P < 0.05$) than lower doses. Optimal doses of XYL and MIX for improving bermudagrass silage DMD were 0.5 (58.2 vs. 55.2%) and 1 (58.4 vs. 55.2%) μl/g, and those for increasing NDFD were 4 (39.7 vs. 32.9%) and 0.5 (36.7 vs. 32.9%) μl/g, respectively. For alfalfa/orchardgrass hay, respective optimal doses for DMD were 1 (68.8 vs. 66.0%) and 0.5 (68.7 vs. 66.0%) μl/g and those for NDFD were 1 (29.6 vs. 22.9%) and 0.5 (27.2 vs. 22.9%) μl/g, respectively. For corn silage, the respective optimal doses for DMD were both 1 μl/g (62.8 and 64.1 vs. 60.7%) and for NDFD they were both 4 μl/g (25.5 and 25.3 vs. 16.3%). Both XYL and MIX increased the in vitro DMD and NDFD of bermudagrass silage, alfalfa/orchardgrass hay and corn silage. Optimal application rates for improving DMD and NDFD differed across substrates for each EFE. The XYL and MIX EFE increased milk production by dairy cows when applied 1 and 3.4 μl/g of TMR DM, respectively in a subsequent trial.

Key Words: forage, enzyme, dose

1585 (M299) A meta-analysis on the effect of fibrolytic enzyme treatment of dairy cow diets. K. G. Arriola[*1], A. T. Adesogan[1], and M. C. Giurcanu[2], *[1]University of Florida, Dep. of Animal Sciences, Gainesville, [2]University of Florida, Dep. of Statistics, Gainesville.*

The objective of this study was to use a meta-analysis approach to summarize the results of experiments that investigated effects of exogenous fibrolytic enzymes (EFE) treatment of diets on the performance of dairy cows. The study evaluated data from 20 studies and 30 experiments. Treatments were classified based on predominant enzyme activities listed by the authors, which included: Cellulase (C)-Xylanase (X) (C-X), Amylase (A), Cellulase-Xylanase-Amylase (C-X-A), Cellulase-Glucose oxidase-Lactobacillus (C-GO-Lac), C-GO-Lac-Amylase (C-GO-Lac-A), Ferulic acid esterase (FAE), Cellulase-FAE (C-FAE), Xylanase-Endoglucanase-Exoglucanase (X-En-Ex), Endoglucanase-Xylanase (En-X), Exogenous proteolytic enzyme (EPE). Data were analyzed with an analysis of covariance model that included effects of study, the EFE type x application rate effect, and the application method (EFE application to the TMR, concentrate or forage). Data were weighted using the inverse of the variance of each study. Among EFE, A increased DMI ($P = 0.029$); C-X increased ($P < 0.05$) DMI, milk yield, lactose yield and NDFD; C-X-A increased ($P < 0.05$) DMI, milk protein yield, DMD, and NDFD; and En-X and EPE increased ($P < 0.05$) only milk protein concentration and milk lactose yield, respectively. Tendencies ($P < 0.1$) were detected for FAE to increase DMI, for En-X to increase feed efficiency (FCM/DMI) and for EPE to increase DMD. Therefore, C-X and En-X were the only EFE that increased milk yield and feed efficiency, respectively. A unit increase in the rates of application of C-X and En-X increased milk yield ($P = 0.017$) and feed efficiency ($P = 0.057$) by 0.19 and 0.18 units, respectively. Applying EFE to the forage increased DMD ($P = 0.003$), whereas application to the concentrate or TMR increased milk lactose yield ($P < 0.001$). Effects of EFE on the performance of lactating dairy cows were equivocal and they depended on the EFE type x rate interaction and the method of application.

Key Words: fibrolytic enzymes, cellulase, xylanase

1586 (M300) Effects of forage particle size and corn oil supplementation related to milk fat depression in dairy cows consuming reduced-fat corn dried distillers grains with solubles. H. A. Ramirez Ramirez* and P. J. Kononoff, *University of Nebraska, Lincoln.*

Four ruminally cannulated Holstein cows averaging (± SD) 116 ± 18 DIM and 686 ± 52 kg of BW were used in a 4 × 4 Latin square with a 2 × 2 factorial arrangement of treatments to test the effects of forage particle size and dietary concentration of

corn oil on milk fat depression (MFD). Cows were housed in individual stalls, milked twice daily and fed once daily to allow ad libitum access to feed. In each 28-d period each cow was offered one of four TMR that differed in forage particle size by inclusion of grass hay (LONG) or grass hay pellets (SHORT) and 0 or 2% corn oil (OIL). Chewing activity was monitored visually every 5 min for 24 h on d 25. Total rumen evacuation was performed on d 27 and 28 of each period to determine rumen kinetics. Dietary treatments were: 0% oil + short particle size (OIL0+SHORT); 0% oil + long particle size (OIL0+LONG); 2% oil + short particle size (OIL2+SHORT); and 2% oil + long particle size (OIL2+LONG). Dry matter intake and milk yield were not affected by treatment averaging 26.5 ± 0.90 kg/d and 32.8 ± 3.25 kg/d, respectively. There was a decrease ($P < 0.01$) in 3.5% FCM due to oil inclusion resulting in 34.6 and 26.6 ± 2.6 kg/d for 0 and 2% oil diets. An oil × size interaction ($P = 0.03$) resulted in 2.26, 3.02, 3.62 and 3.62 ± 0.23% milk fat for OIL2+SHORT, OIL2+LONG, OIL0+SHORT and OIL0+LONG. Fat yield was reduced ($P < 0.01$) from 1.22 to 0.81 ± 0.09 kg/d with 2% oil diets. An oil × size interaction ($P < 0.01$) affected yield of *trans*-10, *cis*-12 conjugated linoleic acid (CLA) resulting in 0.35 g/d for OIL2+SHORT and 0.11 g/d for OIL2+LONG. Long particles increased ($P = 0.02$) eating time from 169 to 198 ± 15 min/d, rumination time ($P < 0.01$) from 400 to 504 ± 35 min/d and reduced ($P = 0.02$) rate of passage of DM from 3.38 to 2.89 ± 0.42%/h. These results demonstrate that dietary manipulations that modify rumen kinetics also impact milk fat production in dairy cows consuming TMR supplemented with corn oil, the effects of corn oil on MFD were less severe when cows consumed long particle size.

Key Words: rumen kinetics, biohydrogenation, chewing activity

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1587 (M301) Impact of forage inclusion rate in a dry total mixed ration on the behavior and growth of growing dairy cattle. M. J. Groen[1,2], M. A. Steele[3], and T. J. DeVries[*1], *[1]University of Guelph, Kemptville, ON, Canada, [2]Wageningen University, Netherlands, [3]Nutreco Canada, Guelph, ON.*

The objective of this study was to determine the impact of forage inclusion rate in a dry TMR on behavior and growth of young dairy cattle. Ten Holstein bull calves (90.5 ± 2.4 d of age, weighing 136.0 ± 12.3 kg) were assigned to one of two treatments, a TMR containing (DM basis) either: 1) 85% concentrate and 15% chopped straw for 10 wk (wk 1 to 10); or 2) 85% concentrate and 15% chopped straw for 5 wk (wk 1 to 5), then 70% concentrate and 30% chopped straw for 5 wk (wk 6 to 10). After 10 wk, all animals were transitioned to a TMR containing (DM basis) 42.3% corn silage and 57.7% haylage for 2 wk (wk 11 to 12). DMI was recorded daily and BW was recorded 2x/wk. Feeding behavior was scored from digital video recordings 3 d/wk. Samples of TMR and orts were taken for particle separation 3 d/wk. Sorting was calculated as: actual intake of each particle fraction expressed as a % of its predicted intake. Data were averaged by week and analyzed in a repeated measures mixed effect model. DMI (5.5 ± 3.3 kg/d), ADG (1.7 ± 0.1 kg/d), feed efficiency (3.5 ± 1.4 kg DM/kg gain), and eating time (151.9 ± 8.8 min/d) were similar between treatments during wk 1 to 5. Calves on the 70% diet ate less DM (5.5 vs. 7.4 kg/d; SE = 0.4; $P = 0.006$), grew slower (1.3 vs. 1.6 kg/d; SE = 0.08; $P = 0.02$), sorted more against long forage particles (62.8 vs. 103.8%; SE = 6.3; $P = 0.01$), and spent a greater duration of time feeding (194.9 vs. 102.6 min/d; SE = 12.5; $P = 0.001$) during wk 6 to 10. A treatment × hour interaction ($P < 0.001$) in the analysis of feeding patterns indicated that this difference in feeding time occurred only during the first 8 h after feed delivery. Despite no differences in DMI (5.2 kg/d) or ADG (1.1 kg/d) in wk 11–12, there was a carryover effect on behavior. In wk 11 to 12, a treatment × hour interaction was detected ($P = 0.03$); calves previously fed the 70% diet continued to spend more time feeding immediately after feed delivery. Interestingly, during wk 11 to 12 those calves did not sort for or against long particles (103.6%), while the calves previously-fed the 85% ration sorted for (107.0%) those particles. These results show that feeding a dry TMR to weaned calves can promote high growth rates and efficiency. Further, altering forage content of such a TMR may have an impact on the expression and persistence of feeding behavior patterns.

Key Words: feeding behavior, forage concentration, straw

1588 (M302) Assessment of feeding high moisture corn grain with different qualities of alfalfa hay in high-forage lactation dairy diets. A. W. Kelley, K. Neal, A. J. Young, and J. S. Eun*, *Utah State University, Logan.*

This experiment was performed to test a hypothesis that quality of alfalfa hay (AH) would affect nutritive benefits of feeding high moisture corn (HMC) due to their associative effects on nutrient utilization efficiency. Eight multiparous lactating Holstein cows were used; four were surgically fitted with ruminal cannula. Days-in-milk averaged 184 ± 10.7 at the start of the experiment. The experiment was performed in a duplicate 4 × 4 Latin square design. Within each square, cows were randomly assigned to a sequence of 4 diets during each of the four 21-d periods (14 d of treatment adaptation and 7 d of data collection and sampling). A 2 × 2 factorial arrangement was used; fair quality AH (FAH; 39.6% NDF and 17.9% CP) or high quality AH (HAH; 33.6% NDF and 21.9% CP) was combined with steam-flaked corn (SFC) or HMC to form four treatments: FAH with SFC, FAH with HMC, HAH with SFC, and HAH with HMC. The AH was fed at 32% DM, whereas HMC was included at 17% DM. Quality of AH did not affect DMI, whereas feeding HMC decreased DMI ($P =$

0.04) regardless of quality of AH. While digestibility of DM increased by cows fed with HAH compared to those fed with FAH (70.1 vs. 67.6%; $P = 0.05$), NDF digestibility increased by feeding HMC (67.6 vs. 58.4%; $P = 0.03$) but not quality of AH. Starch digestibility decreased by feeding HMC with FAH (85.7 vs. 95.0%) but not with HAH, resulting an interaction between quality of AH and type of corn grain (CG; $P = 0.02$). Feeding different qualities of AH did not affect milk yield; however, feeding HMC numerically decreased milk yield in FAH diet, but increased milk yield in HAH (30.4 vs. 29.6 kg/d), causing an AH × CG interaction ($P = 0.05$). Efficiency of milk yield/DMI was improved due to feeding HMC regardless of quality of AH ($P = 0.05$). In addition, dietary N utilization for milk N tended to increase by feeding HMC ($P = 0.07$), but it was not influenced by quality of AH. Overall results in this experiment indicate that feeding HMC in high-forage diets improved feed efficiency as well as N utilization efficiency regardless of quality of AH.

Key Words: alfalfa hay, feed efficiency, high moisture corn

1589 (M303) Replacing corn with soyhulls for late-lactation cows fed high-forage diets. V. R. Moreira*[1], L. K. Zeringue[2], C. Leonardi[3], D. Schilling[2], and M. E. McCormick[2], *[1]Louisiana State University AgCenter School of Animal Sciences, Franklinton, [2]Louisiana State University AgCenter, Franklinton, [3]Louisiana State University, HSC– School of Public Health– Biostatistics, New Orleans.*

The objective was to evaluate performance of 48 late-lactation multiparous Holstein cows (27.6 ± 5.90 kg milk/d, 280 ± 79 DIM) fed rations gradually substituting ground corn (C) with soyhull pellets (SH). Treatments contained 17.4% of dietary DM as C, no SH (C100:SH0); 11.6% C, 5.8% SH (C67:SH33); 5.8% C, 11.6% SH (C33:SH67), and no C, 17.4% SH (C0:SH100). Other dietary ingredients remained similar in all treatments: bermudagrass hay (6.3%, diet DM), corn silage (56%), soybean meal (15.3%), urea (0.5%), calcium carbonate (0.5%), mineral (2.5%), salt (0.5%), and yeast (1%). Fixed ingredients except forages were premixed weekly. Treatments were mixed and offered once daily as TMR. Refusals were weighed and removed before next day feeding. Cows were randomly assigned to treatments for 7 wk following a 2-wk standardization period. Intake and milk yield were recorded daily. Milk samples were collected from one 48-h collection period (2 milkings/d) during pretrial and three collection periods during trial. Milk samples were analyzed for fat, protein, SNF, MUN and SCC. Body weights and body condition scores were recorded at the beginning and end of the experimental period. Two cows were removed before the end of the study because of mastitis (treatments C100:SH0 and C0:SH100). Means were analyzed using PROC MIXEDs (SAS, version 9.3) for main effects of treatment and contrasts were set to test for linear, quadratic and cubic effects of levels of soyhulls substitution for corn. Treatment diets contained 56.5% ± 0.2% DM, 17.0% ± 0.2% CP, 0.91% ± 0.04% Ca, and 0.39% ± 0.02% P as analyzed (average ± standard deviation), and 1.48 Mcal/kg DM as estimated with NRC (2001). Dry matter intake was not affected by treatments (means = 20.8 kg/cow/d; SEM = 0.81), ranging from 19.6 kg for cows fed C67:SH33 to 22.3 kg for those fed C100:SH0. Milk yield averaged 23 kg/cow/d (SEM = 1.55 kg/cow/d) and was not significantly different. Milk fat (3.9%), milk protein (3.3%) and MUNs (18 mg/L) did not differ statistically. There was no evidence supporting better NPN utilization for either feedstuff. Regardless of treatment, cows gained 0.5 kg body weight/d during the study, but body condition score changes in nearly 49 d of study were negligible, averaging 0.04 unit. This study suggests that soyhull pellets can replace corn in late-lactation cows' diets without significantly affect animal performance.

Key Words: ground corn, soyhull pellets, dairy cows

1590 (M304) Effects of different dietary forage sources on milk performance and amino acid profile in early lactating dairy cows. X. Q. Zhou[1,2], D. P. Bu[1], Y. D. Zhang[1], M. Zhao[1], P. Sun[1], and J. Q. Wang*[1], *[1]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [2]Northeast Agricultural University, Harbin, China.*

The objective of this study was to evaluate the effects of different dietary forage sources on performance and milk amino acid profile in early lactation dairy cows. Thirty-two Chinese lactating Holstein cows with similar DIM (55 ± 15 d) and milk yield (31.4 ± 3.49kg/d) were randomly assigned to two groups and fed total mixed ration (TMR) using automatic feeding system. Diets contained similar concentrate mixtures with the same forage-to-concentrate ratio of 36:64 [dry matter (DM) basis]. Different forage sources were then added: 17.30% alfalfa hay and 18.77% corn silage (MF); 36.07% corn straw (CS).Experiment lasted for 90 d, including first 14 d dietary adaption. Animal health condition, milk yield, amount of feed offered and refused for individual cows were recorded every day in experimental period. Milk samples of each cow on 91 d were collected to analysis milk composition and amino acid profile in milk protein. MF group had increased daily DMI(21.35 vs. 17.43 kg/d, $P < 0.01$), milk yield (30.45 vs. 23.12 kg/d, $P < 0.01$), milk protein content (3.66 vs. 3.32%, $P < 0.01$), milk protein yield(1.11 vs. 0.75 kg/d, $P < 0.01$), milk fat yield (1.36 vs. 1.01 kg/d, $P < 0.01$) and milk lactose yield (1.47 vs. 1.13 kg/d, $P < 0.01$) compared with CS group. The content of Thr (3.79 vs. 3.71 g/100 g AA, $P < 0.01$), Ser (4.48 vs. 3.36, $P = 0.03$), Met (3.50 vs. 3.38, $P = 0.02$), Lys (7.71 vs. 7.55, $P < 0.01$) and Arg (3.35 vs. 3.31, $P = 0.02$) in milk protein were elevated significantly in MF group while the two kinds of BCAA (Leu 11.72 vs. 11.88, $P = 0.02$ and

Val 5.98 vs. 6.09, $P < 0.01$) showed an opposite trend. Otherwise, the concentrations of amino acids in milk were greater ($P < 0.01$) in response to MF group compared with CS group. But no difference was observed in content of milk fat and milk lactose between two treatments ($P > 0.05$).

Key Words: forage, milk performance, amino acid

1591 (M305) The partial replacement of corn silage by sugarcane silage plus crude glycerin and the effect of sensory feed additives for dairy cows.

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Crude glycerin may compensate for the energy loss during the ensiling of sugarcane. The partial replacement of corn silage (CS) with an iso-NDF amount of sugarcane silage plus crude glycerin (SG), added or not of sensory feed additives (SA), was evaluated. Thirty-two Holsteins (182 DIM) were individually fed a standardization diet for 2 wk and a treatment for 44 d. The main statistical model contained covariate, block, forage, additive, interaction, time, and its two and three term interactions. Treatments were (% of DM): CS (30.2%) or CS (15%), sugarcane silage (10%), and crude glycerin (3.3%); with or without SA (Luctarom SFS-R 3386-Z and 1353-Z. Lucta, Spain) added to corn and then to forages in the mixer. Diets also contained 9.2% sorghum silage, 4.4% Tifton hay, and 24.5 ± 0.5 forage NDF. SA reduced milk yield in CS (32.2 vs. 31.1 kg/d) and increased in SG (30.3 vs. 31.7 kg/d) ($P < 0.01$ interaction); yields of lactose and solids followed the same trend ($P < 0.05$). SG increased DMI (22.6 *vs.* 21.9 kg/d, $P < 0.01$), while there was a trend for decreased DMI in response to SA (22.5 vs. 22.0 kg/d, $P = 0.07$). The ratio of milk to DMI had a greater positive response to SA in SG (1.34 vs. 1.43) than in CS (1.44 vs. 1.46) ($P = 0.03$ interaction). SG increased the contents of fat ($P = 0.01$) and protein ($P = 0.08$), improving milk solids ($P = 0.03$). There was no effect on feed sorting from 0700 to 1300 h ($P > 0.38$). From 1400 to 1900 h, SG induced selection in favor of particles > 19mm ($P = 0.05$), and, when added to CS, SA induced the rejection of 8- to 19-mm particles and consumption of < 8-mm particles, but had no effect when added to SG ($P < 0.01$ interaction). The intake rate from 0700 to 1300 h was faster in SG ($P < 0.01$), and it tended to be slower when SA was added to CS ($P = 0.05$ interaction). Plasma glucose content was reduced by SA in CS and increased in SG ($P = 0.01$ interaction). PUN did not respond to treatments ($P > 0.39$). There was a trend for reduced plasma γ-glutamyl transferase on SG ($P = 0.09$). Chewing activity was similar across treatments ($P > 0.49$), as well as the daily excretion of urinary allantoin ($P > 0.11$), ruminal fluid pH ($P > 0.24$), and protozoa count ($P > 0.48$). Total tract apparent digestibility was not determined by treatments ($P > 0.39$) neither the intake of digestible OM ($P > 0.72$). The partial replacement of CS by SG plus SA was a plausible alternative for feeding dairy cows.

Key Words: glycerin, sugarcane silage, sorting

1592 (M306) Relative excretion of nitrogen from alfalfa silage, corn silage, corn grain and soybean meal in urine and feces by lactating dairy cows.

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The main objective of this trial is to determine the partitioning of nitrogen (N) from different feed ingredients in milk, feces and urine. This abstract focuses on relative excretion of N in feces and urine. Twelve multiparous late lactation Holstein cows (means ± SD; 264 ± 18 DIM) were fed a pretreatment TMR once a day for 11 d containing (DM basis) 35.5, 28.6, 20.3, 12.9 and 2.6% of corn silage (CS), alfalfa silage (AS), corn grain (CG), soybean meal (SBM) and a mineral and vitamin premix, respectively. On d 12, cows were grouped by milk yield and randomly assigned to one of four dietary treatments corresponding to each feed ingredient at natural abundance of ^{15}N being replaced by its homologue ingredient enriched with ^{15}N (except for CS treatment for which only 75% of the unlabeled CS was replaced by ^{15}N enriched CS). After 4 d feeding the ^{15}N-enriched TMR's, cows were fed the pretreatment non-enriched TMR during d 16 to 19. Total fecal and urinary collection was conducted on each cow every 6 h during d 12 to 19. Feed intake and lactation performance were also measured from d 12 to 19. Data were analyzed as a complete randomized design with treatment as a fixed effect and cow as a random effect. Corn silage and CG had the highest ^{15}N enrichment (atom % ^{15}N of 1.857 and 2.040, respectively) whereas AS and SBM had the lowest (atom % ^{15}N of 0.730 and 1.385, respectively) due to ^{15}N dilution by the atmospherically-fixed N by these legumes. Feeding ^{15}N-enriched ingredients had no effects on DMI (23.2 ± 2.4 kg/d, $P = 0.39$), milk yield (26.1 ± 5.2 kg/d, $P = 0.85$), N intake (601 ± 61 g/d, $P = 0.41$), protein yield (0.89 ± 18 kg/d, $P = 0.80$) and N use efficiency (milk N/N intake; 0.23 ± 0.05, $P = 0.86$). Cumulative ^{15}N recovery (% of total ^{15}N fed) in feces between d 12 and 19 was similar ($P = 0.61$) between AS and CS treatments (29.8 vs. 28.2%), which were greater ($P < 0.05$) than CG (21.5%) and SBM treatments (12.5%). Although not significantly different ($P = 0.12$), greater cumulative ^{15}N recovery (%) in urine was measured in AS (27%), it was intermediate in CS and CG (21.6 and 19.4%, respectively) treatments, and smallest in the SBM (17.0%) treatment. Results from this study suggested that AS and CS contributed most to fecal N excretion and AS contributed most to urinary N excretion.

Key Words: N partitioning, N use efficiency, ^{15}N

1593 (M307) A sensory additive improves performance of dairy cows under heat stress. F. Bargo*[1], S. Muñoz[2], M. Candelas[2], J. Vargas[1], and I. Ipharraguerre[1], [1]*Lucta S.A., Barcelona, Spain,* [2]*Nuplem, Durango, México.*

Five hundred seventy Holstein dairy cows (280 primiparous and 290 multiparous; 194 DIM and 34.4 kg/d milk) from the commercial dairy farm El Trébol (Durango, México) were used to evaluate the effect of a sensory additive (ProEfficient, Lucta S.A.) on dry matter intake, milk production, and feed conversion efficiency under heat stress conditions in a completely randomized design. Cows were grouped by parity (primiparous vs. multiparous) in four free-stall pens and randomly assigned to two treatments: control TMR or the same TMR supplemented with 30 g/d of ProEfficient (PE). The TMR (52:48 concentrate: forage; 18.2% CP, 29.1% NDF, 42.1% NFC) was offered twice daily and PE was top-dressed at each feeding during 34 d starting on June 25ᵗafter 2 wk of adaptation. Daily dry matter intake of each pen and individual milk yield (Alpro, De Laval) were measured. Data were analyzed by ANOVA with a mixed model with repeated measures using the PROC PROC MIXED of SAS (1999) where pen nested within treatment was considered as random effect. During the experimental period, maximum and minimum temperatures averaged 38.9 and 20.4°C, respectively. Dry matter intake increased 1.2 kg/d (23.6 vs. 24.8 kg/d; $P < 0.05$) with the inclusion of the PE additive. Cows fed the TMR with PE produced 2 kg/d more of milk (35.2 vs. 33.2 kg/d; $P < 0.05$) with similar feed conversion efficiency (1.42 kg milk/kg DMI; $P > 0.05$). Based on previous findings from studies with PE, the milk response to this additive could have been related to changes in ingestive behavior (meal size and frequency) and/or positive modulation of hormonal signals associated with the control of feed intake (e.g., ghrelin). Feeding a sensory additive under heat stress conditions increased dry matter intake and milk production of dairy cows fed a TMR.

Key Words: sensory additive, heat stress, intake and milk production

1594 (M308) Performance and health of calves pre- and post weaning fed milk replacers with supplements for heat abatement in the summer months. H. Chester-Jones*, *University of Minnesota Southern Research, and Outreach Center, Waseca.*

Two studies were conducted in the summer of 2012 and 2013 to evaluate pre- (d 1 to 42) and post-weaning (d 43 to 56) calf performance and health when fed milk replacers (MR) with supplements to aid in heat abatement. Calves were fed a non-medicated 20% fat:20% CP MR at 0.284 kg in 1.99 L water (12.5% solids) 2x/d for the first 35 d and 1x/d from d 36 to weaning at 42 d. From d 1 to 14, 1:1 neomycin:oxytetracycline was added to the MR solution to provide 22 mg/kg BW daily. Calf starter (CS; 18% CP) and water were fed free choice d 1 to 56. In study 1, 51 (2- to 4-d-old) individually fed Holstein heifer calves (38.5 ± 0.96 kg) were assigned to MR supplements as follows: SA1 = none; SA2 = B-complex vitamin premix fed at 1.42 g/calf daily and SA3 = betaine fed at 5 g/calf daily. There were no treatment differences in pre- and post-weaning ADG or total hip height (HH) gain which averaged 0.64 kg and 9.63 cm, respectively. There was a trend ($P < 0.10$) for increased 56-d CS intake when calves were fed the SA2 or SA3 compared to SA1 MR (0.81 vs. 0.72 kg DM/d). There were no differences in BW gain, total DMI, gain/feed or scouring days across treatments. Calves fed SA2 had higher ($P < 0.05$) daily health treatment costs vs. SA1 calves but were not different from SA3 calves ($P = 0.07$). In study 2, 75 (2- to 4-d-old) individually fed Holstein heifer calves (39.4 ± 0.65 kg) were assigned to MR supplements SB1, none; SB2, B-complex vitamin premix fed as in study 1 and SB3, B-complex vitamins as in SB2 plus an electrolyte mix fed at 28 g/calf daily. There were no treatment differences in ADG and HH gain (0.68 kg and 10.85 cm, respectively over the 56-d study). Pre-weaning gain/feed was higher ($P < 0.05$) for SB3 compared to SB1 or SB2 calves. There were no differences in health parameters. A heat index of 90 or more occurred on 34 d in 2012 and 26 d in 2013 studies, respectively. Under the conditions of these studies, heat abatement supplements added to MR did not consistently enhance calf performance.

Key Words: milk replacers, heat abatement supplements, performance

1595 (M309) Performance and health of calves pre- and post weaning fed milk replacers with supplements for heat abatement in the summer months. D. Schimek*[1], B. Ziegler[1], D. Ziegler[2], H. Chester-Jones[2], and M. Raeth-Knight[3], [1]*Hubbard Feeds Inc., Mankato, MN,* [2]*University of Minnesota Southern Research and Outreach Center, Waseca,* [3]*University of Minnesota, St. Paul.*

Two studies were conducted in the summer of 2012 and 2013 to evaluate pre- (d 1 to 42) and post-weaning (d 43 to 56) calf performance and health when fed milk replacers (MR) with supplements to aid in heat abatement. Calves were fed a non- medicated 20% fat:20% CP MR at 0.284 kg in 1.99 L water (12.5% solids) 2x/d for the first 35 d and 1x/d from d 36 to weaning at 42 d. From d 1 to 14, 1:1 neomycin:oxytetracycline was added to the MR solution to provide 22 mg/kg BW daily. Calf starter (CS; 18% CP) and water were fed free choice d 1 to 56. In study 1, 51 (2- to 4-d-old) individually fed Holstein heifer calves (38.5 ± 0.96 kg) were assigned to MR supplements as follows: SA1 = none; SA2 = B-complex vitamin premix fed at 1.42 g/calf daily and SA3 = betaine fed at 5 g/calf daily. There were no treatment differences in pre- and post-weaning ADG or total hip height (HH) gain which averaged 0.64 kg and 9.63 cm, respectively. There was a trend (*P*

< 0.10) for increased 56-d CS intake when calves were fed the SA2 or SA3 compared to SA1 MR (0.81 vs. 0.72 kg DM/d). There were no differences in BW gain, total DMI, gain/feed or scouring days across treatments. Calves fed SA2 had higher ($P < 0.05$) daily health treatment costs vs. SA1 calves but were not different from SA3 calves ($P = 0.07$). In study 2, 75 (2- to 4-d-old) individually fed Holstein heifer calves (39.4 ± 0.65 kg) were assigned to MR supplements SB1, none; SB2, B-complex vitamin premix fed as in study 1 and SB3, B-complex vitamins as in SB2 plus an electrolyte mix fed at 28 g/calf daily. There were no treatment differences in ADG and HH gain (0.68 kg and 10.85 cm, respectively over the 56-d study). Pre-weaning gain/feed was higher ($P < 0.05$) for SB3 compared to SB1 or SB2 calves. There were no differences in health parameters. A heat index of 90 or more occurred on 34 d in 2012 and 26 d in 2013 studies, respectively. Under the conditions of these studies, heat abatement supplements added to MR did not consistently enhance calf performance.

Key Words: milk replacers, supplements, performance

1596 (M310) Effect of supplementing heat stressed dairy cows with electrolytes on milk yield, composition, and blood metabolites. C. J. Cabrera*, S. H. Ward, and A. J. Geiger, *Mississippi State University, Starkville.*

The objective of this study was to determine the effect of supplementing electrolytes from -21 to 30 DIM to heat stressed cows on DMI, MY, and blood metabolites. A total of 104 Holstein and Jersey, cows and heifers, were utilized between August–September 2012 and August–November 2013. Before calving, all cows and heifers were fed ryegrass baleage in the morning and TMR in the evening (CON) or the same base ration plus 270 g of electrolyte (E+, Bovine Bluelite, TechMix, Inc; MN) providing balanced electrolytes (0.55% Ca; 0.30% P; 9.60% NaCl; 8.25% K; 0.14% Mg). Post-calving, CON cows were fed standard TMR and E+ cows received the same TMR plus 270 g of Bovine Bluelite. DMI, MY, rectal temperature, and respiration rate were monitored daily; while blood metabolites, body weight, condition score and frame (withers height, hip height, and heart girth) were measured weekly. Orts and feedstuffs were sampled weekly and subjected to proximate analysis. Milk samples were taken weekly and analyzed for fat, protein, solids, lactose content, and SCS. Blood samples were taken via jugular venipuncture, further analyzed for pH, HCO3, tCO2, pCO2, Anion Gap, Na^+, K+, and Cl^-, using an onsite IDEXX Blood Gas Analyzer, and for hematocrit utilizing a micro centrifuge. DMI was not different among treatments, however, during 2013 dry cows consumed more than in 2012 (8.33 vs. 7.09 kg/d; $P < 0.0001$). Cows fed E+ had lower MY than CON cows (29.64 vs. 34.99 kg/d; $P = 0.0042$). Holstein cows averaged greater MY than Jerseys (36.45 vs. 28.18 kg/d; $P < 0.0001$) but despite this expected breed effect, MY for CON and E+ cows only differed between Holsteins (40.90 vs. 32.00 kg/d, respectively; $P < 0.0001$), not between Jerseys (29.08 vs. 27.29 kg/d, respectively; $P = 0.6084$). Milk composition was not affected, however, E+ cows had increased fat content ($P < 0.001$) weekly for the first 4 wk, whereas CON cows decreased ($P < 0.001$) until wk 2. Respiration rate (57.12 vs. 55.30 bpm; $P = 0.1197$) and rectal temperature (38.7 vs. 38.7°C, respectively; $P = 0.9853$) were not influenced by treatment, but Holstein cows had greater respiration rates than Jerseys (58.63 vs. 53.78 bpm, respectively; $P < 0.0001$). No differences were observed in blood metabolites, nor in body weight change and condition score, except for withers height which was greater for CON cows (133.40 vs. 130.75 cm, respectively; $P = 0.0170$). Electrolyte supplementation did not increase MY, nor affect any of the other measured variables in the present study.

Key Words: dairy, electrolyte, transition

1597 (M311) Average daily gain among calves fed a high plane of milk replacer during the pre-weaning period is not associated with improved reproductive efficiency or lactational performance in Holstein heifers. M. D. Sellers*, C. R. Nightingale, and M. A. Ballou, *Texas Tech University, Dep. of Animal and Food Sciences, Lubbock.*

The objective was to determine if increased ADG while on a high plane of nutrition during the pre-weaning period is associated with improved reproductive efficiency as a heifer and improved reproductive efficiency or lactational performance as a primiparous cow. Seventy-two Holstein calves from a single herd in western Texas (2 ± 1 d old) were fed a high plane of nutrition (28/20 milk replacer fed at 756 g/d DM and 1010 g/d DM for the first wk and wk 2 through 6, respectively, with ad libitum access to calf starter grain during the pre-weaning period. Weaning was initiated at wk 7 with the removal of PM milk replacer feeding and was completed when starter intake was 800 g/d DM after d 53. Daily milk replacer and starter intakes were recorded, and ADG was calculated for the pre-weaning period (wks 1 to 7). All calves were returned to the dairy of origination 3 mo after weaning and were managed according to their standard procedures. Reproductive efficiency as a heifer, as well as first lactation reproductive efficiency and milk production were collected from DairyComp305 records. All descriptive data will be reported as [0, 25, 50, 75, and 100 percentile]. The pre-weaning ADG was [0.144, 0.491, 0.560, 0.636, and 0.827 kg/d]. There was no relationship between pre-weaning ADG and age at first calving [647, 672, 685, 721, and 776 d; $P = 0.14$]. Reproductive performance as a primiparous cow was not affected by pre-weaning ADG, as no relationship was observed for average days open [61, 83, 104, 173, 298 d; $P = 0.14$. In addition, there was no relationship between pre-weaning ADG and first lactation production metrics of peak milk [28.2, 35.9, 39.1, 41.8, and 50 kg; $P = 0.15$] and estimated 305 d mature

equivalent [8191, 10827, 11914, 13407, 16073 kg; $P = 0.32$]. Additional research is needed to evaluate the relationship between post-weaning heifer nutrition and health statuses and subsequent reproductive and lactational performance.

Key Words: calf, lactation performance, plane of nutrition

1598 (M312) Ruminal in situ DM and starch digestion descriptive statistics of corn silage and high moisture corn. C. R. Heuer*[1,2], J. P. Goeser[1,2], and R. D. Shaver[3], *[1]Dep. of Dairy Science, University of Wisconsin–Madison, Madison, [2]Rock River Laboratory, Inc, Watertown, WI, [3]University of Wisconsin, Madison.*

Starch comprises 20 to 35% of dry matter (DM) in diets for lactating dairy cows. Ruminal starch digestibility is highly variable across and within feed types. Our objective was to determine ruminal in situ starch digestibility (StarchD) for corn silage (CS; $n = 52$) and high moisture corn (HMSC; $n = 41$) samples. Samples were dried at 50°C in a forced air oven for 48 h and ground to pass through a 1-mm Udy Mill screen for DM and starch analysis, or a 6-mm Wiley Mill screen for ruminal in situ analysis. Rumen in situ samples were weighed with 3 g per bag in an Ankom 5x10-cm bag (50µm pore size) in triplicate. Bags were soaked in warm water before incubation. One bag was placed in three different ruminally-cannulated lactating dairy cows consuming a 58% forage diet with a 50:50 ratio of corn silage to legume (DM basis). Samples were incubated for 3 and 7 h; all bags were removed simultaneously. Following incubation the bags were rinsed until effluent was clear. Bags were dried at 50°C for 24 h and weighed to determine the DM digestibility (DMD). Residue samples were composited and ground to pass a 1-mm Udy Mill screen. Starch content was then determined according to a modified M.B. Hall 2008 procedure using an YSI2700 (YSI Life Sciences On-Line Biochemistry Analyzer), to determine glucose after samples were enzymatically digested, instead of theglucose oxidase–peroxidase procedure. StarchD was calculated as the difference in grams of starch remaining in the residue, relative to the grams of starch in the sample. DMD and StarchD descriptive statistics were analyzed using SAS JMPv10 and are presented in Table 1598. Ruminal in situ StarchD was highly variable for HMSC and CS.

Key Words: rumen, starch, digestion

Table 1598. Rumen in situ 3 and 7-h descriptive statistics of DMD and StarchD

Type	Hour	Mean	St.dev.	Min.	Max.	C.V
Dry Matter Digestion (%)						
HMSC	3	40.3	16.6	19.0	82.5	41.2
HMSC	7	50.6	12.8	28.8	86.6	25.3
CS	3	41.6	10.2	15.5	57.5	24.5
CS	7	48.4	8.4	22.3	66.9	17.4
Starch Digestion (%)						
HMSC	3	47.1	15.0	26.0	91.2	31.8
HMSC	7	58.2	12.9	36.6	91.3	22.2
CS	3	64.7	18.6	0.9	88.2	28.7
CS	7	77.0	14.5	16.8	93.8	18.8

1599 (M313) Response of rumen fermentation to urease inhibitor using dual-flow rumen simulation system. P. P. Wang[1], D. Jin[1], J. Q. Wang*[2], D. P. Bu[2], and S. Zhao[1], *[1]State Key Laboratory of Animal Science, Institute of Animal Science, Chinese Academy of Agricultural Science, Beijing, China, [2]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijng, China.*

The objective of this study was to investigate urea degradation using a novel dual-flow rumen simulation system. Eight fermentation vessels (1 L) were allotted to a 2 × 2 factorial arrangement of treatments with urea supplemented at 0 or 0.5% dry matter intake (DMI), and urease inhibitor equivalent to 0 or 450 mg/kg DMI. A total of 40 g of DM with urea were fed in two equal portions daily, while the urease inhibitor, contained approximately 98% (w/w) acetohydroxamic acid (AHA), was added in the artificial saliva infused into the vessels twice daily. The experimental period consisted of 6 d for adaptation and 3 d for sampling. On each sampling Day 15 mL fermentation fluids were obtained from each fermentation vessel by syringes at 0, 2, 4, 6, 8, and 10 h, respectively. Temperature (39°C), liquid, and solid dilution rates (8%/h and 200 mL/d, respectively) were maintained through the whole process. Both protozoa numbers and dry matter disappearance (DMD) ($P = 0.62$ for urea; $P = 0.47$ for AHA) from each fermentation vessel were not affected by urea or AHA supplementation. Urea supplementation significantly ($P < 0.01$) increased pH and ammonia-nitrogen (NH_3–N) concentration, and AHA addition increased ($P = 0.03$) urea-N concentration. There was no interaction between urea and AHA. The pH reached the peak value at 2 h with urea supplementation only, and the pH began to reduce at 4 h with both urea and AHA addition. NH_3–N concentration arrived at maximum at 2 h with urea and/or AHA supplementations, but it sharply ($P < 0.05$) decreased at 4 h with urea supplementation and at 6 h with both urea and AHA addition. Urea-N concentration of treatment with urea and AHA supplementation was sustainably higher than other

treatments until 6 h. It was concluded that AHA inhibited urea degradation but had no effect on ammonia formation.

Key Words: dual-flow rumen simulation system, fermentation, urease inhibitor

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1600 (M314) Effects of four ruminant feed additives on in vitro ruminal fermentation kinetic gas production and degradability. J. Li[1,2], J. Q. Wang[1], P. Sun[1], F. D. Li[2], and D. P. Bu[*1], *[1]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, [2]College of Animal Science and Technology, Gansu Agricultural University, Lanzhou, China.*

This experiment was designed to investigate the effects of four ruminant feed additives, *Bacillus subtilis*, *procreatin* (major ingredient was high-enriched live yeast), *Aspergillus oryzae* culture and fibrase (major ingredient was *Aspergillus oryzae, Aspergillus niger* and lactic acid yeast) on gas production (GP) kinetics of different doses of 0(control), 1.0, 2.0, 4.0mg/kg diet (DM), respectively. Ruminal fluid was collected approximately 2 h before feeding from three lactating Holstein dairy cows (BW = 558 ± 10 kg, DIM = 153 ± 16d) fed total mixed ration (C:F = 40:60) and mixed with McDougall's phosphate buffer (v/v = 1:2). 500mg diet substrates, which were consistent with the donor cows, were incubated with diluted buffered rumen fluids (75ml) for 72 h at 39°C. The batch completed in 2 experimental runs, and 4 fermentations per treatment were arranged in each run. All bottles were connected to gas channel inlets of Automated Trace Gas Recording System for Microbial Fermentation (AGRS, Beijing, China). Data on the cumulative gas production were fitted to a model: GP_t (ml/g DM) = $A/(1+(C/t)^B)$. Where GP_t was the cumulative gas production (ml/g DM) at t incubation time (h), A was the asymptotic gas production (ml/g DM), B was a sharpness parameter determining the shape of the curve and C was the time (h) at which half of A is reached. A, B and C were calculated by the nonlinear procedure of SAS. There was no difference of C in all treatments ($P > 0.05$). Regarding to *Bacillus subtilis*, the GP_{72} ($P = 0.08$), A ($P = 0.09$) tended to linearly decrease with increase of adding levels, while B tended to increase ($P = 0.06$). For procreatin, the GP_{72} ($P = 0.06$) tended to quadratically increase and A quadratically increased ($P < 0.05$), however, the doses did not affect B ($P > 0.05$). The addition of *Aspergillus oryzae* linearly increased the GP_{72} ($P < 0.01$) and A ($P < 0.01$) and had a tendency for B ($P = 0.09$). The GP_{72} ($P < 0.05$) and A ($P < 0.05$) linearly increased with the rise of fibrase addition levels and no difference in B. In vivo digestibility of animal feeds was estimated by measuring in vitro GP of feed samples incubated in ruminal fluid buffered. The results suggested that *Aspergillus oryzae* and fibrase addition could increase the extent and rate of feed degradation while *Bacillus subtilis* and procreatin addition had slightly effects.

Key Words: feed additives, gas production, in vitro

1601 (M315) Comparison of omasal and reticular sampling methods on ruminal nutrient outflow and digestion in lactating dairy cows. S. M. Fredin[*1], L. F. Ferraretto[1], M. S. Akins[2], and R. D. Shaver[1], *[1]University of Wisconsin, Madison, [2]University of Wisconsin, Platteville.*

An experiment was conducted to compare omasal and reticular sampling methods on ruminal nutrient outflow and digestion in lactating dairy cows fed normal- or reduced-starch diets. Eight ruminally-cannulated multiparous Holstein cows (96 ± 8 DIM at trial initiation) were randomly assigned to a 2 × 2 factorial arrangement of treatments in a replicated 4 × 4 Latin square design with 21-d periods. Treatments were finely (F; mean particle size = 552 μm) and coarsely (C; 1270 μm) ground dry shelled corn in normal (NS) and reduced (RS) starch diets fed as TMR. The NS and RS diets contained 27 and 18% starch (DM basis), respectively, by partially replacing corn grain with soy hulls. Continuous infusion of flow markers Cr-EDTA and YbCl began on d 15. Spot samples of omasal digesta were collected four times daily every 2 h on d 18 to 20, with a 6-h interval between sampling days to represent a 24-h feeding cycle. A 250-mL digesta sample was taken from the reticulum immediately after omasal digesta collection. Indigestible NDF, determined after a 288-h ruminal in situ incubation, was used as a large particle marker and digesta samples were reconstituted using the triple-marker system. Data was analyzed using Proc Mixed of SAS. Dry matter intake was 23.2 ± 1.6 kg/d across all treatments ($P > 0.43$). Marker concentrations were greater in omasal samples compared with reticular samples ($P < 0.001$), resulting in increased ($P < 0.001$) estimates of apparent ruminal digestibility of NDF (39.1 vs. 37.8%), and starch (83.5 vs. 78.9%) for omasal sampling. Outflow of starch from the rumen was greater ($P < 0.01$) for reticular sampling (1.0 vs. 0.8 kg/d), however outflow of NDF was similar ($P = 0.82$) between sampling methods (4.1 kg/d). Ruminal NDF digestibility was greater ($P < 0.001$) for RS compared to NS for omasal samples (43.4 vs. 34.9%, respectively). Unexpectedly, the diets containing C resulted in greater ruminal starch digestibility ($P = 0.02$) compared with F for omasal (85.0 vs. 82.2%, for C and F, respectively) or reticular samples (81.4 vs. 76.5%, for C and F, respectively). Although differences for ruminal nutrient digestibility estimates between sampling methods were observed, they were relatively minor. Therefore, reticular sampling appears to be an acceptable method to estimate ruminal nutrient outflow and digestibility.

Key Words: dairy cow, omasal sampling, reticular sampling

1602 (M316) Validation of a new approach to estimate total tract fiber digestibility from in vitro NDFD values. F. Lopes*[1], K. Ruh[1], D. K. Combs[2], L. F. Ferraretto[1], S. M. Fredin[1], C. Arndt[1], R. D. Shaver[1], and L. E. Armentano[1], *[1]University of Wisconsin, Madison, [2]Dep. of Dairy Science University of Wisconsin, Madison.*

The objective was to validate an in vitro model to predict the total tract fiber digestibility (TTNDFD) in dairy cattle. Nineteen diets from six different trials conducted at University of Wisconsin–Madison were analyzed for fiber digestibility using the in vitro standardized model (Goeser and Combs, 2009). Forages varied amongst diets (corn, alfalfa, tall-fescue and meadow fescue and wheat straw silages) and nutrient composition (NDF ranges from 22.5 to 32.1%, CP 15.8 to 18.9% and NFC 38.0 to 51.0%). Total NDF digestibility observed from the in vivo trials was calculated using indigestible NDF or lignin as marker analyzed in fecal, diet and orts samples. The in vitro TTNDFD model predicts total tract fiber digestibility from the rate of pdNDF degradation (kd, ranges from 1.5 to 4.8%/h), the rate of passage of pdNDF (kp, ranges from 2.5 to 2.8%/h) and the proportion of total NDF that is potentially digestible. The kd is calculated from in vitro NDFD measurements taken at 24, 30, and 48 h of incubation using first order kinetics model with an indigestible fraction (Mertens, 1993). Passage of potentially digestible fiber is predicted from a regression model (Krizsan et al., 2010) for iNDF which is adjusted to account for the selective retention of pdNDF (Lund et al., 2006). The pool of indigestible fiber was estimated from 240 h in vitro NDF residues. Data were analyzed using SAS procedure of logistic regression. The coefficient of determination (R^2) was used to measure the proportion of variation explained by the model. The range of in vivo TTNDFD was 26.3 to 55.6% compared to 33.8 to 52.8% for predicted in vitro TTNDFD. The relationship between predicted in vitro TTNDFD and in vivo TTNDFD was TTNDFD in vivo = −5.7531 + 1.1561 TTNDFD in vitro predicted with R^2 of 61.6%, Root-MSE of 4.3% and P-value of < 0.001. The in vitro test of diets from six different trials demonstrated that TTNDFD model can provide important insights into fiber utilization by dairy cattle that could be used in the field. The TTNDFD value can also be used as a stand-alone value to index forages, as already shown in other publications from our lab. The ability to predict total tract fiber digestibility from a model based on in vitro NDF degradation and incorporate this information into rations could improve our ability to optimize forage utilization and milk production.

Key Words: iNDF, fiber, digestibility

1603 The effects of supplementation with a blend of capsicum, cinnamaldehyde, and eugenol on milk production performance of dairy cows. R. Blanck*[1], K. Vecht[1], C. Oguey[2], and E. Wall[2], *[1]Bar-Magen, Emek Hefer, Israel, [2]Pancosma, Geneva, Switzerland.*

Essential oils are naturally-occurring chemicals in plants, and many of these molecules have been reported to influence production efficiency of dairy and beef animals. Previously, it was reported that a blend of capsicum, cinnamaldehyde, and eugenol increases feed efficiency of beef steers. Our objective was to determine if that same additive (EO; Xtract®-7065, Pancosma) would influence the milk production performance of lactating dairy cows during the summer months in Israel. In two consecutive field trials, Holstein dairy cows were assigned to no additive or supplementation with EO (1 g/d; n = 30 cows/treatment in trial one, 70 cows/treatment in trial two; n = 2 pens/treatment) for 4 mo. The EO was blended with ground corn meal and top-dressed; control cows received corn meal without EO. Dry matter intake (DMI) per pen was calculated daily and individual cow milk production, milk composition, and somatic cell count (SCC) were recorded monthly. Data were subjected to analysis of variance with repeated measures using pen as the experimental unit and trial as a random variable. Cow activity was monitored in the first trial using a pedometer (Afimilk, Isreal), and rumination minutes per day were measured in the second trial (SCR, Israel). Those data were analyzed using analysis of variance with repeated measures and cow as the experimental unit. Milk production was increased in EO cows (39.4 vs. 42.0 kg/d; $P < 0.01$) with no effect of EO on DMI (22.6 vs. 22.5 kg/d; $P > 0.70$). Consequently, there was an improvement in feed efficiency of EO cows (milk/DMI = 1.74 vs. 1.89; $P < 0.001$). There was no effect of EO on milk composition ($P > 0.50$), but there was an increase in energy-corrected milk with EO (40.1 vs. 42.2 kg/d; $P < 0.01$). In addition, there was a decrease in SCC of EO cows (306.1 vs. 242.4 cells*1000/ml; $P < 0.05$). In trial one, there was a decrease in activity of EO cows (165 vs. 137 steps/d; $P < 0.001$); however, in trial two, there was no effect of treatment on rumination time (425 vs 436 min/d; $P = 0.30$). We conclude that a blend of capsicum, cinnamaldehyde, and eugenol can increase milk production and feed efficiency of lactating dairy cows. Additional experiments are needed to confirm these observations and to understand the mechanism underlying the response of dairy cows to EO.

Key Words: essential oil, feed additive, phytonutrient

1604 (M318) Stochastic analysis of the effects of variation in corn silage composition on the supply of metabolizable energy and protein in lactating dairy cows. J. Ferguson*, Z. Wu[1], D. T. Galligan, L. Baker, and N. Thomsen, *University of Pennsylvania, Kennett Square.*

The UPENN Ration Balancer, based on CPMDairy and CNCPS 5.1 with modifications, was used to construct a stochastic model to evaluate the influence of variation in corn silage (CSG) composition on the supply of ME and MP and their allowable milk production. Proximate analysis of CSG samples (n = 514) from 63 PA farms defined the mean and range in nutrient composition (CP, soluble protein (SP), NPN as a percent of SP, NDF, starch, sugars, water soluble fiber, silage acids, fat, and ash) and NDF degradation rate (Kd) for model inputs. A diet was formulated using mean CSG nutrient content and Kd to meet the ME and MP requirements for a cow (675 kg BW) producing 45.0 kg/d milk with 3.7% fat and 3.1% true protein and a DMI of 24.1 kg/d with the following ingredients (% DM): CSG (41.54), alfalfa haylage (6.22), grass silage (8.30), corn grain (21.98), soybean meal (12.64), Soy Pass (5.51), Energy Booster (0.62), blood meal (1.02), minerals and vitamins (2.12), and an amino acid supplement (0.06). The basal diet composition was as follows (% DM): CP 17.7, NDF 29.0, starch 30.1, sugars 3.4, water soluble fiber 5.3, silage acids 4.2, fat 3.9, and ash 6.5. The mean, SD and nutrient correlation matrix of CSG composition was used to construct an @Risk model (Palisade Corporation, NJ) to exam the influence of stochastic variation in nutrient composition of CSG on ME and MP supply. Five thousand simulations were run varying CSG composition and consequently TMR composition. The influence of CSG nutrient content variation on ME and MP allowable milk was as follows: Lignin content of CSG had the major influence on both ME and MP supply followed by NDF kd and NDF and starch. Lignin and NDF digestion should be included in forage analysis of CSG.

Key Words: corn silage, production, nutrient content

Table 1604.

Nutrient (%DM)	CSG Content			Range in Allowable Milk, kg/d (in rank)			
	Mean	Min.	Man.	ME		MP	
Lignin	3.0	1.9	5.9	Lignin	3.32	Lignin	2.61
NDF Kd, %/h	3.8	1.3	6.6	NDF Kd	2.19	Starch	2.36
NDF	42.0	31.9	58.0	NDF	2.06	NDF	2.03
Starch	31.5	9.3	49.7	Starch	1.27	NDF Kd	1.37
Ash	3.7	1.6	8.8	Ash	1.07	SP	1.02
Fat	3.3	1.2	5.6	Fat	1.04	NPN, % SP	0.44
SP	4.4	1.6	7.4	SP	0.52	CP	0.41
CP	7.7	5.4	10.9	CP	0.37	FAT	0.22
NPN, % SP	60.5	20.9	100.0	NPN, % CP	0.16	Ash	0.20

1605 (M319) Extruded soybean meal increases feed intake and milk production in dairy cows. T. Frederick*[1], F. Giallongo[1], J. Oh[1], H. Weeks[1], A. N. Hristov[1], D. M. Kniffen[1], and R. A. Fabin[2], *[1]Dep. of Animal Science, Pennsylvania State University, University Park, [2]Fabin Bros. Farms, Indiana, PA.*

Extruded soybean meal (ESBM) has higher fat content and lower ruminal protein degradability than solvent-extracted soybean meal (SSBM), but information on its nutritive value for dairy cows is limited. A replicated 3 × 3 Latin square design trial with nine Holstein cows (*P*arity, 3.1 lactations; DIM and BW at the beginning of the trial, 161 ± 21 d and 637 ± 20.3 kg, respectively) and 28-d experimental periods was conducted to evaluate the effect of ESBM processed at two extruder temperatures, 149°C (LTM) and 171°C (HTM), on milk production and composition and blood plasma amino acid profile in dairy cows. The control diet contained 13% SSBM [53.8% crude protein (CP) with 71.4% ruminal degradability and 1.8% ether extract (EE)], which was replaced with equivalent amount (DM basis) of LTM (46.8% CP, 59.8% degradability, 10.0% EE) or HTM (46.9% CP, 41.1% degradability, 10.9% EE) ESBM in the two experimental diets (LTM and HTM, respectively). Other ingredients in the diets were (DM basis): 40% corn silage, 20% alfalfa haylage, 5% grass hay, 9% ground corn grain, 5% cottonseed hulls, 5% molasses, salt, urea (LTM and HTM diets only), and mineral-vitamin premix. The diets had 16% CP and met or exceeded the NE_L and metabolizable protein requirements of the cows (NRC, 2001). Both LTM and HTM tended to increase (P = 0.06) DMI compared with the control diet (28.3, 28.2, and 26.8 kg/d, respectively). This resulted in increased ($P < 0.001$) milk yield for both ESBM diets: 40.2 and 40.8 vs. 37.5 kg/d, respectively. Milk fat (3.38 to 3.60%) and milk true protein (2.86 to 2.95%) contents and milk fat yield were not affected by treatment. Milk protein yield tended to be increased (on average by 60 g/d; P = 0.09) by the ESBM diets. Plasma urea N and MUN were increased ($P < 0.03$) 18 and 13%, respectively, by the ESBM diets compared with the control. Blood plasma concentrations of His, Leu, and Val were increased ($P \leq 0.03$) by HTM compared with the control and LTM. Concentration of plasma Met was decreased (P = 0.05) and that of carnosine was increased (P = 0.02) by the ESBM diets compared with the control. This study demonstrated that replacement of SSBM with ESBM in the diet of lactating dairy cows increased feed intake, which resulted in increased milk yield, and increased milk protein yield.

Key Words: solvent-extracted soybean meal, extruded soybean meal, dairy cow

1606 (M320) Effect of inclusion of canola meal or wheat dried distillers grains with solubles on ruminal fermentation, omasal nutrient flow, and production performance in lactating Holstein dairy cows fed two levels of forage: concentrate. M. E. Walpole, G. E. Chibisa, and T. Mutsvangwa*, *University of Saskatchewan, Saskatoon, Canada.*

Canola meal (CM) and wheat distillers grains with solubles (W-DDGS) are high quality protein sources for lactating dairy cows, which are readily available for use in western Canada and parts of the U.S.A. When comparing the amino acid profile of CM and W-DDGS, CM generally has higher levels of lysine; however, ruminal degradability of CM is lower than that of W-DDGS. It is generally accepted that increasing ruminally-available N while increasing dietary ruminally-fermentable energy (e.g., by altering the forage:concentrate [F:C] ratio) can improve the rate of microbial protein synthesis in the rumen. Therefore, the objective of the current study was to examine the effects of differing F:C levels (45:55 vs. 55:45) when the main source of dietary protein was either CM or W-DDGS on milk production and composition, ruminal pH, and omasal nutrient flow. Eight lactating dairy cows (100 ± 58 DIM) were used in a replicated 4 × 4 Latin square design with 28-d periods (20 d adaptation + 8 d measurements) and a 2 × 2 factorial arrangement of dietary treatments. Four cows in one Latin square were ruminally-cannulated for measurements of ruminal fermentation and omasal nutrient flow. Diets were isonitrogenous (15.5% CP). Interactions between dietary source of protein x F:C ratio were not significant. Dietary treatment had no effect on DM intake ($P > 0.05$). Source of protein had no effect on milk yield and composition ($P > 0.05$); however, cows fed diets with the low F:C ratio tended to have higher milk ($P = 0.06$) and milk protein yields ($P = 0.07$), but had a lower milk fat content ($P = 0.04$) and milk urea nitrogen ($P = 0.02$) compared to those fed the high F:C ratio. Milk fat yield was unaffected by dietary F:C ratio ($P > 0.05$). Ruminal ammonia and mean pH were unaffected by dietary treatment ($P > 0.05$). Omasal DM flow was not affected by dietary treatment ($P > 0.05$). Apparent ruminal DM digestibility was numerically greater in cows fed the diet with the low F:C ratio when compared to those fed the high F:C ratio ($P = 0.11$). Total N intake, and omasal N flow were unaffected by dietary treatment ($P > 0.05$). In conclusion, both CM and W-DDGS are suitable protein sources when lactating dairy cows are fed diets varying in F:C ratio.

Key Words: canola meal, milk production, wheat dried distillers grains with solubles

1607 (M321) Analysis of dipeptidyl peptidase IV from microbial metagenomic library in the rumen of dairy cow. J. W. Zhao*[1], J. Q. Wang[2], S. G. Zhao[2], and D. P. Bu[2], [1]*College of Animal Science and Technology of Inner Mongolia University for the Nationalities, Tongliao, China,* [2]*State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China.*

The study for sequence characteristics and enzymatic properties of dipeptidyl peptidases IV (DPP-IV), which is the key enzyme of oligopeptide degradation, will contribute to searching for it inhibit targets, reduce the dipeptide generating speed, and then decrease ammonia generation, thereby improve nitrogen efficiency. The DPP-IV gene of DP7 clone which could reduce the dipeptide activity of crude enzyme from microbial metagenomic library in the rumen of dairy cow was studied. Two primers were designed using DPP-IV gene (GenBank: JX466878) from DP7 clone, and plasmid of DP7 clone was direct sequenced. The structural feature of DPP-IV gene was analyzed by bioinformatics method and DPP-IV gene was expressed in BL21 competent cell. The DPP-IV gene expression sequence was obtained from PCR amplification of DP7 clones using sequence expression primer, and the target protein of DPP-IV was acquired by prokaryotic expression and purification. The analysis of DPP-IV gene sequence showed it had one open reading frame with 2298 bp length (756 amino acid residue) containing the characteristic catalytic domain GWSFGG found in all known DPP-IVs and the conserved region DWVYEEE. The results of BLASTP analysis showed the highest similarity of sequences derived from *Pontibacter sp* DPP-IV (46% identity), followed by *Sphingobacterium sp* (46%), *Solitalea canadensis* (46%), *Marinilabilia sp* (45%) and *Cecembia lonarensis* (45%). DPP-IV gene of DP7 had the identification of the catalytic triad (Ser-633, Asp-708 and His-740), and an inserted amino acid sequence from 422 to 445 compared with other organisms. The results demonstrated DPP-IV gene obtained from DP7 was a new sequence of DPP-IV. The molecular weight of target protein was consistent with the predicted molecular weight (78 kDa) indicating that the enzymatic properties of DPP-IV could proceed with further study.

Key Words: dipeptidyl peptidases IV, gene expression, sequence analysis

1608 (M322) Modification of the feeding behavior of dairy cows through live yeast supplementation. T. J. DeVries*[1] and E. Chevaux[2], [1]*University of Guelph, Kemptville, ON, Canada,* [2]*Lallemand Animal Nutrition, Milwaukee, WI*

The objective of this study was to determine if the feeding behavior of lactating dairy cows can be modified through live yeast supplementation. Twelve lactating Holstein dairy cows (2 primiparous and 10 multiparous) were individually

exposed to each of two treatment diets (over 35-d periods) in a replicated crossover design. Treatment diets were: 1) control TMR, and 2) control TMR plus $1x10^{10}$ cfu/head/d live yeast (*Saccharomyces cerevisiae* CNCM I-1077; Levucell SC20; Lallemand Animal Nutrition, Montreal, QC, Canada). Milk production, feeding, and rumination behavior were electronically monitored for each animal for the last 7 d of each treatment period. Milk samples were collected for the last 6 d of each period for milk component analysis. Data were analyzed in a general linear mixed model. DMI (28.3 kg/d), eating time (229.3 min/d) and rate (0.14 kg DM/min) were similar between treatments. With yeast supplementation, meal criteria were shorter (20.0 vs. 25.8 min; SE = 2.3; $P = 0.04$), translating into cows tending to have more meals (9.0 vs. 7.8 meals/d; SE = 0.6; $P = 0.07$), which tended to be smaller in size (3.4 vs. 3.8 kg/meal; SE = 0.2; $P = 0.09$). Meal length (33.9 min) was similar between treatments. Yeast supplemented cows also tended to ruminate longer (570.3 vs. 544.9 min/d; SE = 13.2; $P = 0.08$). Milk yield (45.8 kg/d) and efficiency of production (1.64 kg milk/kg DMI) were similar between treatments. There was a tendency for higher milk fat % (3.71 vs. 3.55%; SE = 0.08; $P = 0.09$) and yield (1.70 vs. 1.63 kg/d; SE = 0.04; $P = 0.1$) when cows were supplemented yeast. No differences in milk fatty acid composition were seen, with the exception of a tendency for a greater concentration of 18:2, *cis*-9, *cis*-12 fatty acid (2.71 vs. 2.48% of total FA; SE = 0.13; $P = 0.08$) when cows were yeast supplemented. Yeast supplemented cows had lower mean ruminal temperature (38.4 vs. 38.5°C; SE = 0.01; $P = 0.02$), spent less time with rumen temperature above 39.0°C (353.1 vs. 366.9 min/d; SE = 5.5; $P = 0.001$), and tended to spend less time with rumen temperature above 38.0°C (693.9 vs. 780.0 min/d; SE = 29.1; $P = 0.06$). The results suggest that live yeast supplementation had a beneficial impact on rumen fermentation as evidenced by improvements in meal patterns and rumination, milk fat production, and rumen temperature.

Key Words: live yeast, rumination, meal pattern

1609 (M323) The effect of supplementing dairy cows with a hydrolyzed yeast product (ProgutRumen) on milk production and somatic cell scores.

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The object of this study was to determine if supplementing Holstein-Friesian cows with hydrolyzed yeast product (ProgutRumen) had an effect on milk production and somatic cell score (SCS). Holstein-Friesian dairy cows ($n = 248$) were balanced for DIM, pre-experimental milk yield, and milk composition and assigned to either a control ($n = 127$) or hydrolyzed yeast (Progut, $n = 121$) treatment. Cows were put into two large pens and after each milking the cows were rotated into a new pen to account for environmental effects in the shed. Cows were individually fed the Control and Progut Rumen (10 g/cow/day) treatments in the milking parlor during the morning milking. Therefore, the cow was considered the experimental unit. The trial was performed over two seasons (for a 10-wk period and a 8-wk period) and on weekly intervals milk yield was recorded and milk composition (fat yield and %, protein yield and %, lactose yield and %) and somatic cell score was determined. The dataset was divided in three ways for the analysis; the entire dataset, all cows with an average daily milk yield > 24kg, and finally all cows with an average daily milk yield > 30kg. All data were analyzed in SAS with a repeated measures mixed model with the appropriate covariance structure determined by Bayesian Information Criterion. The fixed effects included treatment, season, parity (1 to ≥ 5), and week and the interactions between treatment and parity, and treatment and week with a random effect included for cow. There were no significant differences between the Control and Progut Rumen treatments for the milk composition traits. There was a significant increase in milk yield for the Progut Rumen treatment in the entire dataset ($P < 0.01$), > 24kg dataset ($P < 0.01$) and the > 30 kg dataset ($P < 0.05$). There was a significant decrease in SCS for Progut Rumen compared to the Control treatment in the entire dataset ($P < 0.01$), > 24kg dataset ($P < 0.05$) and the > 30 kg dataset ($P < 0.05$). In conclusion supplementing dairy cow diets with Progut Rumen did not alter milk composition, however it increased milk yield and decreased SCS indicating possible beneficial effects on the dairy cows' immune system.

Key Words: hydrolysed yeast, milk yield, somatic cell score

1610 (M324) Effect of live yeast vs. sodium sesquicarbonate supplementation on milk yield and milk components in dairy cows.

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The trial objective was to determine the effect of supplemental live yeast (LY) ($10x10^9$ cfu/cow/d; *Saccharomyces cerevisiae* CNCM I-1077) vs. sodium sesquicarbonate (SS) (227 g/cow/d) on milk yield, milk components, and DMI. Four pens of Holstein cows (200–230 cows/pen) in a freestall barn were paired as follows: Parity 1 and Parity 2+. Each pair was balanced pre-trial for parity, DIM, milk yield, and milk components. One pen per pair received LY and one pen per pair received SS. The study was 16 wk in length with 12 wk of diet adaptation and 4 wk of data collection. Parity 1 and Parity 2+ diets were similar except Parity 2+ contained 25% BMR corn silage and forage NDF was higher (24.26 vs. 23.45%).

Daily milk yield of individual cows was recorded. Individual milk components were assessed twice with a 2-wk interval between tests. Data was analyzed using JMP statistical software. Only cows remaining in study pens for the entire 16 wk were included (LY = 295 cows; SS = 279 cows). The statistical model for milk yield and components included treatment, DIM category, and pair as fixed effects with cow within pen as random. Pre-trial milk yield and componentswere included as covariates. Pair-wise comparisons were recalculated using JMP's contrast analysis which utilizes Student's *t* test. The statistical model for DMI used treatment and pair within treatment as fixed effects. Daily milk yield (kg/d) was unaffected by treatment. Weekly average daily milk yields around component test days tended ($P = 0.10$) to be higher for LY, especially in Parity 2+ cows (42.08 vs. 40.26 kg/d for LY and SS, respectively (SE = 0.56)) ($P = 0.01$). Percent milk fat and milk true protein were not affected ($P > 0.10$) by treatment. For all cows, yield of 3.5% FCM tended to be 1.29 kg higher with LY ($P = 0.08$) but for mature cows only, yield of 3.5% FCM was significantly higher with LY (45.66 vs. 43.56 kg/cow for LY and SS, respectively (SE = 0.63)) ($P = 0.01$). Live yeast improved ($P = 0.02$) overall milk true protein yield by 0.04 kg/d. Mature cows responded to LY with higher DMI (28.24 vs. 26.88 kg/d for LY and SS, respectively) ($P < 0.01$). Yield of milk and milk components was similar or higher with LY. Mature cows consuming a diet with more digestible forage NDF had a greater positive 3.5% FCM yield response to LY than first-lactation cows.

Key Words: live yeast, sodium sesquicarbonate, milk yield, milk components

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1611 (M325) Milk production of dairy cows fed sugarcane silage based diets.
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This study aimed to evaluate the use sugarcane silage for Holstein high and medium producing cows. The treatments consisted of corn silage (CS) in forage: concentrate ratio 60:40, and four diets based on sugarcane in forage: concentrate ratio 40:60:fresh sugarcane (FSC), sugarcane silage control (SCC), sugar ane silage with *Lactobacillus buchneri* (SCLB), and sugarcane silage with *Lactobacillus plantarum* plus *Pediococcus pentosaceus* (SCLP). Fifteen cows were blocked for milk production (25, 30, and 35 kg/day), and were evaluated in five periods of 15 d. Animals were distributed in a randomized block design in a scheme of repeated measures. Data was analyzed according to the follow contrasts: CS vs. sugarcane diets; FSC vs. sugarcane silage diets; SSC vs. sugarcane silage with additives; SCLB vs. SCLP. DM, OM, NDF, NFC intakes did not differ between treatments ($P > 0.05$). The digestible OM intake was also not affected ($P = 0.05$). CP intake was greater ($P = 0.02$) for diets containing sugarcane silage. CS had higher DM ($P = 0.04$) and OM ($P = 0.03$) digestibility compared to diets containing sugarcane silage. It was also observed that digestibility of NDF in CS was greater ($P = 0.02$) than other diets, and SCLB promoted the lowest vules of NDF digestibility. We observed no differences ($P = 0.580$) for production of milk (25,8 kg/day), corrected milk 4% fat (23.19 kg/day), milk fat (3.34%), milk lactose (4.00%) and total solids (11.43%), whereas there was a higher crude protein content in milk ($P = 0.04$) for FSC (3.09%) and lowest level for SCLP (2.62%). Sugarcane diets contained higher levels of plasma urea nitrogen (*P*UN; 0.010), and FSC presented lower values compared to others sugarcane diets. Urea nitrogen in urine (UNU) and microbial efficiency (EFMIC) did not differ between diets ($P > 0.05$). The average daily gain (ADG) also did not differ ($P = 0.42$) between treatments (0.31 kg/day). It was concluded that diets with 60% concentrate added to sugarcane silage can allow support mean yields 25.8 kg/day of milk, similarly to other bulky sources.

Key Words: digestibility, milk, consumption

1612 (M326) Fecal sample starch content deteriorates over time after sampling.
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Dairy and beef cattle fecal samples are typically taken from commercial dairies and feedlots to assess starch utilization. Greater fecal starch content is related to lesser ruminal and total tract starch degradation and animal performance. Fecal sample starch concentration may change during time in transit to analysis laboratory, which in some cases can be 5 d or more. Dairy cattle fecal samples (at least 10 250-g subsamples) were collected from manure piles at each of two commercial dairies in Wisconsin in July 2013. Subsamples were thoroughly mixed, immediately split on farm into air-tight plastic containers (250 g), and stored for 0 (control), 1, 2, or 5d. Samples stored for 1, 2, or 5d were also held at approximately 2°C (cold), 22°C (room), or ambient (variable, daily high 27°C) temperatures. The 0-h sample was processed on the same day samples were gathered. These combinations were organized in a factorial arrangement and chosen to simulate sample environment during shipping to analysis lab. Samples were oven dried (50°C for 48 h) and ground to 1 mm following treatment. Starch content (% of DM) was measured in each sample and total tract starch digestibility (% of starch, TTSD) was calculated using the Ferraretto and Shaver 2012 equation: 100 X (0.9997- 0.0125 × fecal starch). Data were analyzed with multiple linear regression using SAS JMPv10 and model effects chosen using forward selection. Temperature and time were entered as fixed effects and farm was random. Temperature ($P < 0.05$) and time ($P < 0.01$) were significantly related to fecal starch content and predicted TTSD. Fecal starch content

averaged 4.3, 5.4, 4.3, and 4.1% for control, cold, room, and ambient temperature exposures, respectively. The numerically greater starch content at cold-storage temp relative to control was unexplained, and warrants further evaluation. Fecal starch content raw data averaged 5.4 and 3.7% at 0 and 5d, respectively. Predicted TTSD data averaged 93.3 and 95.4% at 0 and 5 d, respectively. Model parameter slope estimates were -0.017 and 0.02 per h for fecal starch and TTSD, respectively. Results warrant further evaluation, but suggest fecal starch content and animal digestion estimates will change during extended time in transit. The amount of time between sampling and starch analysis should be considered and minimized.

Key Words: fecal, starch, digestion

1613 (M327) Effects of pH and incubation duration on the stability of the endoglucanase activity of seventeen exogenous fibrolytic enzyme preparations. A. F. Campos[1], B. Y. Coy[2], K. G. Arriola[*2], and A. T. Adesogan[2], *[1]São Paulo State University, Dep. of Animal Science, Brazil, [2]University of Florida, Dep. of Animal Sciences, Gainesville.*

This study examined effects of pH and incubation duration on the stability of the endoglucanase activity of various exogenous fibrolytic enzymes (EFE). Seventeen commercial EFE sourced from *Trichoderma reesei* or and *Aspergillus spp.* were assayed in triplicate for endoglucanase (EN) activity at pH 4.0, 5.0 and 6.0 after incubation for 0, 24, 48, and 168 h at 40°C. Endoglucanase activity was assayed in a 15-mL tube containing 1.0 mL of 1.0% (wt/vol) carboxymethyl cellulose as substrate and 0.9 mL of citrate-phosphate buffer (pH 4.0, 5.0 or 6.0). For the 0-h incubation, after a 10-min preincubation period, 0.1 mL of diluted EFE was added to cellulose to initiate the reaction and the suspension was incubated for 5 min. The reaction was terminated with 3 mL of dinitrosalicylic acid. For the other incubation periods, tubes were kept in a water bath at 40°C degrees for the respective durations. The unit of EN activity was the amount of EFE required to release 1 µmol of reducing glucose equivalents min^{-1} mg^{-1}. Treatments were arranged in a 17 (enzymes) × 3 (*P*H) × 4 (incubation duration) factorial layout and data were analyzed with a model including these terms and the interactions using the GLM procedure of SAS. Endoglucanase activity was greatest ($P < 0.0001$) for all EFE at pH 4.0 after 0 h of incubation except for one EFE, which exhibited the greatest activity at pH 6.0 after 0 h of incubation. For 13 of the 17 EFE, increasing the incubation duration or the pH quadratically ($P < 0.0001$) decreased EN activity. However, simultaneously increasing the pH and incubation duration linearly ($P < 0.0001$) decreased EN activity. Within 24 h of incubation, between 97.9 and 99.6% of the EN activity was lost from each EFE. Therefore, EN activity decreased substantially as the incubation duration increased. This study shows that the EN activities of the EFE decreased with increasing pH and or incubation time. Endoglucanase activities were much lower at the usual ruminal pH of lacting dairy cows than at those (pH 4 to 5) typically used to assay EFE activities in the laboratory.

Key Words: endoglucanase, exogenous enzyme, incubation duration, pH

1614 (M328) Evaluation of a source of α-amylase and a protease in the diet of lambs on nutrient intake and digestibility and blood parameters. *B*. Quintana[*1], L. C. Solorzano[2], and A. A. Rodriguez[1], *[1]University of Puerto Rico, Mayaguez, [2]DSM Nutritional Products, Parsippany, NJ.*

The effects of a commercial source of α-amylase and an experimental protease or their combination on nutrient intake and digestibility and blood parameters were determined in lambs fed 21% dietary starch. Twelve crossbred lambs (14.2 kg) were assigned to one of four diets; no additive (control) or diets containing α-amylase (RONOZYME RumiStar), an experimental protease, or their combination. Diets were offered daily at 4% of animal BW/DMB in four 28-d experimental periods consisting of 21 d of adaptation to the diet followed by 7 d of complete fecal collection. In each period, feed offered, orts, and feces were collected, quantified, and analyzed for DM, starch, CP, and NDF contents to determine intake and digestibility. Disease incidence was observed and recorded during the experiment. Blood samples were collected from each lamb at the end of each experimental period to determine glucose, BHB, NEFA, and insulin concentrations. Data were analyzed according to a 4 × 4 Latin Square experimental design. Treatments contrasts were performed using least squares means adjustment for multiple comparisons (Tukey-Kramer) between diets as follows: containing enzymes versus no enzymes, amylases versus no amylases, proteases versus no proteases, and amylases versus proteases. Adding proteases to the diet decreased ($P < 0.05$) starch consumption as compared to that of lambs fed without the experimental enzyme (248.5 vs. 255 g/d). Starch digestibility also tended ($P < 0.10$) to be higher in lambs fed with the protease than with α-amylase (98.9 vs. 98.5%). Adding enzymes to the diet tended ($P < 0.10$) to decrease BHB concentration (4.26 vs. 4.68 mg/dL). NEFA concentration tended to decrease ($P < 0.10$) for lambs fed α-amylase as compared to lambs fed diets without α-amylase (0.128 vs. 0.156 mEq/L). Insulin levels were lowered ($P < 0.05$) by addition of α-amylase in lambs diets as compared to those of animals fed with protease (73.3 vs. 80.3 pmol/L). Insulin level also tended ($P < .10$) to increase in lambs fed the experimental protease as compared to lambs fed the enzyme (80.3 vs. 78.7 pmol/L). In summary, adding the experimental proteases to lambs diets containing 21% dietary starch decrease starch consumption and tended to increase starch digestibility. Both exogenous enzymes influenced blood metabolites; however, a greater effect was observed in lambs fed with the experimental protease.

Key Words: enzymes, α-amylase, protease

1615 (M329) Evaluation of a source of α-amylase and a protease in the diet of lambs on nutrient intake and digestibility and blood parameters. B. Quintana*[1], L. C. Solorzano[2], and A. A. Rodriguez[1], *[1]University of Puerto Rico, Mayaguez, [2]DSM Nutritional Products, Parsippany, NJ.*

The effects of a commercial source of α-amylase, an experimental protease or their combination on nutrient intake and digestibility and blood parameters were determined in lambs fed a basal diet of 34% ground corn, 40% tropical grass hay, and 26% soybean meal providing 21% dietary starch. Twelve crossbred lambs (14.2 kg) were assigned to one of four diets: no additive or diets containing α-amylase (RONOZYMERumiStar), an experimental protease, or their combination. Diets (DM basis) were offered daily at 4% of animal BW in four 28-d experimental periods consisting of 21 d of adaptation to the diet followed by 7 d of complete fecal collection. In each period, feed offered, orts, and feces were collected, quantified, and analyzed for DM, starch, CP, and NDF contents to determine intake and digestibility. Disease incidence was observed and recorded during the experiment. Blood samples were collected from each lamb at the end of each experimental period to determine glucose, BHB, NEFA, and insulin concentrations. Data were analyzed according to a 4 × 4 Latin Square experimental design. Treatments contrasts were performed using least squares means adjustment for multiple comparisons (Tukey-Kramer) between diets as follows: enzymes versus no enzymes, amylase versus no amylase, protease versus no protease, and amylase versus protease. DM intake was similar across treatments (1106.1, 1087.5, 1104.8 and 1088.5 g/d for control, and diets containing α-amylase, experimental protease or their combination, respectively). Adding protease to the diet decreased ($P < 0.05$) starch consumption as compared to that of lambs fed without the experimental enzyme (248.5 vs. 255 g/d). Starch digestibility tended ($P < 0.10$) to be higher in lambs fed the protease than α-amylase (98.9% vs. 98.5%). Adding enzymes to the diet tended ($P < 0.10$) to decrease BHB concentration (4.26 vs. 4.68 mg/dL). NEFA concentration tended to decrease ($P < 0.10$) for lambs fed α-amylase compared to lambs fed diets without α-amylase (0.128 vs. 0.156 mEq/L). Insulin levels were lowered ($P < 0.05$) by addition of α-amylase in lambs diets as compared to those of animals fed with protease (73.3 vs. 80.3 pmol/L). Insulin level also tended ($P < .10$) to increase in lambs fed the experimental protease as compared to lambs fed the enzyme (80.3 vs. 78.7 pmol/L). In summary, adding the experimental protease to lambs diets containing 21% dietary starch decreased starch consumption and tended to increase starch digestibility. Both exogenous enzymes influenced blood metabolites, however a greater effect was observed in lambs fed the experimental protease.

Key Words: enzymes, amylase, protease

1616 (M330) Utilization of industrial enzymes in the evaluation of neutral detergent insoluble fiber content in high-starch samples. C. Batista Sampaio*[1], D. I. Gomes[2], E. Detmann[3], S. de Campos Valadares Filho[1], H. Valentim Nunes Machado[4], and M. de Oliveira Franco[1], *[1]Universidade Federal de Viçosa, Dep. of Animal Science, Minas Gerais, Brazil, [2]Universidade Federal do Pará, Parauapebas, Pará, Brazil, [3]Universidade Federal de Viçosa, Minas Gerais, Brazil, [4]Universidade Federal de São João Del Rei, Minas Gerais, Brazil.*

The method of analysis of fibrous components called "detergent system" was initially developed to evaluate forage and subsequently extended to other types of feeds. However, its application to analizing non-fibrous feeds is associated with some analytical problems, noticiably with high starch feeds. The use of a α-amylase is recomemended by AOAC International as a standard procedure to promote solubilization of the starch in feeds samples to obtain insoluble fiber with accuracy. Diferent amylases are available for industrial activities, which have, in general, certificated quality and activity. However, the type and amount of industrial enzymes that could potentially be used in evaluating the insoluble fiber have not established. It were performed two experiments to evaluate the utilization of industrial enzymes in the evaluation of neutral detergent fiber (NDF) contents in high-starch materials. In the first experiment, it was verified the accuracy of estimates of NDF obtained with the utilization of three industrial enzymes (Termamyl 2X, Liquozyme Supra 2.2.X, and Amylase AG 300L-Novozymes) at different volumes (50, 100, 250 or 500 μL/sample). Samples were simulated to contain starch at 0, 100, 300, 500, and 1000 g/kg using purified cellulose and starch ($n = 240$). Estimates of the bias of NDF contents were evaluated by analysis of variance, acording in a completely randomized design in a 3 × 4 × 5 (three types and four volumes of enzymes and five concentrations of starch). In the second experiment, samples of corn grain and sorghum grain were evaluated considering the same enzyme types and volumes used in the first experimente, also incluiding aliquots without using enzyme addition ($n = 104$). There was no significant bias of NDF recovery for simulated samples containing starch up to 300 g/kg ($P > 0.01$). Considering those samples, none difference among enzymes was observed ($P > 0.01$). The results obtained from the evaluation of corn and sorghum suggest the use of 250 μL volume and enzyme necessary for the extraction of starch. Therefore, it can be recommended the utilization of 250 μL the α-amylases evaluated.

Key Words: α-amilase; feed analysis; fiber

1617 (M331) In situ degradation and fermentation of a diet with an exogenous phytase for lambs.

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Close to 70% of phosphorus (*P*) from cereal grains and oleaginous seeds is linked to phytic acid as phytate, which is little utilized or not at all by non-ruminants. Diets containing more than 50% of the P as phytate will decrease hydrolysis of the phytate by rumen microorganisms. Therefore, the objective of this in situ trial was to evaluate the effect of an exogenous phytase added to a diet for lambs. Treatments were: 0, 540, and 720 g of phytase Ronozyme-HiPhos (DMS Nutritional Products, 5000 FTU/g) added to a 70% sorghum grain diet and fed to six Criollo lambs (40 ± 2 kg live BW) with ruminal and duodenal cannulas, and housed on individual metabolic cages during 45 d (plus 15 d for adaptation). The experimental design was a 3 × 3 Latin square repeated on time, data were analyzed using GLM procedure (SAS v. 9.2) and treatment means were compared with the Tukey test ($P \leq 0.05$). Variables were dry matter intake (DMI), pH and VFA concentration in ruminal fluid, NH_3–N and P concentration in ruminal and duodenal fluid, fecal and urine P, and plasma P; samplings were performed at 3, 6, 9, 12, 24, 48, and 72 h. Phytate of the diet was 67.74% of the total P. For 0, 540, and 720 g phytase, differences ($P \leq 0.05$) were found only for DMI (1053.32ab, 988.70b, 1141.32a g/day) and fecal P (2.32a, 2.01ab, 1.85b % P/g DM). Thus, it may be concluded that this exogenous phytase did not change pH, VFA, P in ruminal fluid, P in urine or plasma. But since fecal P excretion was reduced, soil contamination could be decreased.

Key Words: phytase, P excretion, lamb.

1618 (M332) Sources of sulfur in protein supplements and fiber degradability.

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The present work is focused on the evaluation of different sulfur sources in protein supplements for cattle. Crossbred steers were fed with *Brachiaria dictyoneura* hay, with different sulfur sources in the protein supplement: 70S elementary sulfur (ES70S); 98S elementary sulfur (ES98S); hydrated calcium sulfate (HCS); anhydrous calcium sulfate (ACS) and ammonium sulfate (AS). The nutritional effects observed to the steers in relation to the different sulfur sources were evaluated by means of different aspects, such as nutrient intake, apparent digestibility, fiber degradability and particle flow-rate. An 11:1 nitrogen:sulfur ratio was employed, being that five steers fistulated in the rumen and abomasum were utilized through distribution in a 5 × 5 Latin square. The different sulfur sources in the supplement did not affect ($P > 0.05$) the intakes of dry matter of hay; crude protein (CP); neutral detergent fiber corrected for ash and protein (NDFap); organic matter (OM); nonfiber carbohydrate (NFC); ether extract (EE); and total digestible nutrients (TDN). The respective sulfur sources do not generated significant alterations ($P > 0.05$) regarding the digestibility coefficients of NDFap and CP.

In this study, NDF degradation profiles were encountered in agreement with the solid transit kinetics parameters model and estimations. The data were adjusted to different double-compartment models (G1G1, G2G1, G3G1, G4G1, G5G1 and G6G1). The models G2G1, G3G1, G5G1, G4G1 and G3G1 were more efficient in accordance with the estimations of the following treatments: G2G1 to 70S elementary sulfur; G3G1 to 98S elementary sulfur; G5G1 to calcium sulfate (hydrated gypsum); G4G1 to calcium sulfate (anhydrous gypsum) and G3G1 to ammonium sulfate. It was possible to infer that the sulfur sources employed in the present work influenced slightly the ruminal fiber degradation.

Key Words: degradability, fiber, intake, nitrogen sulfur ration

Table 1618. Medium values and coefficients of variation (CV) for daily intake of dry matter (DM), crude protein (CP), neutral detergent fiber corrected for ash and protein (NDFap), organic matter (OM), total digestible nutrients (TDN), as function of sulfur sources in the protein supplements

Item	ES70S	ES98S	HCS	ACS	AS	CV(%)
			g/kg BW			
Hay DMI	17.08	17.31	16.71	17.18	17.11	4.66
			kg/day			
CP	0.48	0.47	0.47	0.47	0.45	7.46
NDFap	3.76	3.76	3.60	3.74	3.79	4.90
OM	4.19	4.17	4.00	4.14	4.18	5.14
NDT	3.04	3.15	2.73	2.51	2.62	17.67

1619 (M333) Effect of weight gain rates in the post-weaning phase and forage allowance in the finishing phase with high supplementation on performance of Nellore cattle. *V*. A. C. Mota[1], G. F. Berti[2], J. A. Alves Neto[3], R. M. Fernandes[4], P. H. Gonçalves[2], B. C. Carvalho[2], M. A. P. Alves[2], I. M. de Oliveira*[5], F. D. D. Resende[5], and G. R. Siqueira[5], *[1]UNESP/FCAV, Jaboticabal, Brazil, [2]Centro Universitário da Fundação Educacional de Barretos–Unifeb, Barretos, Brazil, [3]Universidade Estadual Paulista, Jaboticabal, Brazil, [4]UNESP-FCAV, Jaboticabal, Brazil, [5]APTA–Agência Paulista de Tecnologia dos Agronegócios, Colina, Brazil.*

The study analyzed the effect of forage allowance in the finishing phase of beef cattle fed high levels of supplementation and its interaction with the rate of weight gain in the post-weaning phase. Sixty four non-castrated Nellore cattle with an average body weight (BW) of 386.0 kg, were distributed into 16 paddocks (experimental units) of *Brachiaria brizantha* cv. Marandu and fed 2% of their BW in supplement containing 34% of corn, 51% of citrus pulp pellets and 15% of mineral mix. Treatments consisted of animals managed during the post-weaning phase on 15- or 35-cm-tall pastures receiving mineral mix 50 g/100 Kg BW and sub-divided into lots with low and high forage allowance in the finishing phase. In the post-weaning phase, the pasture height provided different ADG (0.761 kg d^{-1} for the 15 cm and 1.076 kg d^{-1} 35 cm pasture), and different forage allowances were obtained in the finishing phase, with the same stocking rate in the paddocks, with different initial masses (3.370 and 8.470 kg DM ha^{-1}) provided by the management of 15- and 35-cm-tall pastures during the post-weaning phase, respectively. The experimental period was 120 d, in a completely randomized blocks design in a 2 × 2 factorial arrangement, in which data were analyzed by using a mixed model through the PROC MIXED of SAS (SAS 9.2), significance at $P < 0.10$ by the *t* test. The animals that had the lowest weight gain and were in the treatment with the highest forage allowance in finishing had the greatest ADG (1.123 kg d^{-1}; $P = 0.02$), and the other nutritional strategies did not differ from each other ($P > 0.10$), averaging 0.929; 0.901 (biggest gain in post-weaning and low and high bid on finishing respectively) and 0.920 kg d^{-1} (lower gain in post-weaning and finishing in low supply). The supplement intake was affected by the post-weaning treatment ($P = 0.01$) and no effect of forage allowance in the finishing was observed ($P = 0.74$). Animals kept on 35-cm pastures in the post-weaning started the finishing heavier consumed more supplement (7.8 kg d^{-1}) than those reared on 15-cm pastures (7.3 kg d^{-1}). In relation the quantity of concentrate to gain 1 kg of BW, the animals on the lowest forage allowance level in the finishing showed an upward trend ($P = 0.15$; 7.7 vs. 8.9 kg supplement kg BW). *Supported by CAPES/UNESP/CONNAN.*

Key Words: gain, consumed, Marandu

1620 (M334) Nutritional evaluation of forage Kochia (*Kochia prostrata*) as an alternative forage for beef cattle using a dual-flow continuous culture system. E. Marostegan de Paula*, L. Galoro da Silva, T. Shenkoru, Y. L. Yeh, J. Bunkers, and A. Faciola, *University of Nevada.*

Forage Kochia (FK; *Kochia prostrata*) has the potential to be used as forage for beef cattle due to its high nutritional value and ability to grow well on soils with low moisture content. The objective of this experiment was to determine the nutritional value and rumen fermentation characteristics of FK as compared to alfalfa hay (AH) and orchardgrass hay (OH). Diets were randomly assigned to six dual-flow continuous culture fermenters (1200 to 1250 mL) in a replicated 3 × 3 Latin square arrangement with three 10-d experimental periods consisted of 7 d for diet adaptation and 3 d for sample collection. Fermenters were fed a total of 72 g of DM/d equally divided in 12 portions of one of three diets: 1) 100% AH, 2) 100% OH, and 3) 100% FK. Liquid and solid dilution rates were adjusted daily to 10%/h and 5%/h, respectively. A sample of 500mL from each fermenter was taken on d 8, 9, and 10. Two subsamples of 10ml were filtered through two layers of cheesecloth, and were preserved with 0.2 mL of 50% sulfuric acid and were centrifuged for subsequent ruminal NH_3–N and VFA analysis. Statistical analyses were performed using the GLM procedure in SAS. There were no differences ($P > 0.05$) among treatments for total VFA, molar proportion of acetate, propionate, butyrate, and branched-chain VFA (Table 1620). However, there were differences ($P < 0.05$) for NH_3–N. Ruminal NH_3–N observed was greater for FK compared with AH and OH, indicating a greater N availability for microbial growth; nevertheless, there were no significant differences between AH and OH. Results from this experiment indicated that FK may be a viable alternative for beef cattle producers. This is especially important for areas in which conventional forages may not grow well such as the U.S. Great Basin area.

Key Words: forage Kochia, alfalfa hay, in vitro fermentation

Table 1620.

	Treatment				
	AH	OH	FK	SEM	*P*-value
Diet Composition	——— %DM ———				
CP	15.7	10.3	20.9		
NDF	40.2	61.3	37.9		
NH3-N, mg/dL	1.23[b]	0.77[b]	2.76[a]	0.37	0.04
Total VFA, mmol	90.6	85.6	91.0	5.78	0.77
Acetate, %	74.8	72.0	73.9	2.72	0.77
Propionate, %	17.1	18.3	16.8	1.94	0.85
Butyrate, %	6.1	7.6	6.7	1.05	0.60
Isobutyrate, %	0.23	0.18	0.30	0.03	0.23
Valerate, %	1.37	1.47	1.44	0.25	0.95
Isovalerate, %	0.34	0.36	0.56	0.09	0.30
Acetate:Propionate	5.1	3.9	4.8	0.62	0.45
Total BCVFA, mmol	2.2	1.8	2.4	0.48	0.70

1621 (M335) Effect of using either barley straw or alfalfa hay on intake and digestibility in growing Simmental heifers fed high-concentrate diets.

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The objective of this experiment was to compare the effects of using two different forage sources on intake and digestibility in growing heifers fed high-concentrate diets. Eight Simmental heifers (141 ± 15.5 d old and with an average initial BW of 147.4 ± 10.8 kg) were used in a crossover design experiment. Treatments tested were: a) total mixed ration with barley straw as forage source (BS), and b) total mixed ration with alfalfa hay as forage source (AH). Forages were coarsely chopped before their incorporation to total mixed ration. Diets were offered on an ad libitum basis, with a forage to concentrate ratio of 8:92, and formulated to be isocaloric (2.91 Mcal ME/kg DM) and isonitrogenous (15% CP on DM basis). The experiment was performed in two 28-d periods, and sampling was performed in the last week of each period. Heifers were weighed before feeding on two consecutive d at the beginning and at the end of the experiment, and the first and last d of the sampling week. Feed offered and refusal samples of each heifer were collected daily for 7 d in the sampling week for DM determination and chemical analysis. Dry matter digestibility was estimated using acid-insoluble ash as an internal marker. Fecal samples were collected from the rectum at d 6 and 7 of each sampling period. Differences were analyzed by using the PROC MIXED of SAS. The model contained the fixed effects of treatment, period and their interaction, and the random effect of heifer nested within sequence. Intake of DM, CP and NDF was unaffected by treatment, being on average 6.4, 0.8 and 1.6 kg/d, respectively. Average daily gain of heifers fed BS tended to be greater than that of heifers fed AH (1.7 and 1.5, respectively; $P = 0.10$). Gain to feed ratio tended ($P = 0.07$) to be greater in heifers fed BS than AH (0.29 and 0.27, respectively). Dry matter digestibility and intake of digestible DM was unaffected by treatment, being on average 63.5% and 4.1 kg/d, respectively. In conclusion, at 8% of incorporation, barley straw tended to result in a better performance than alfalfa hay when these forage sources were offered as total mixed ration to growing beef heifers.

Key Words: beef cattle, forage source, high concentrate diet

1622 (M336) Metabolism of nitrogenous compounds in beef cattle fed tropical forage supplemented with protein in the rumen, abomasum or both.

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Four Nellore steers, averaging 280 ± 10 kg BW, fitted with ruminal and abomasal cannulas were used in a 4 × 4 balanced Latin square design to evaluate the effect of protein supplementation in the rumen and/or abomasum on N metabolism in cattle fed tropical forage. The treatments were: 1) control (without supplementation); 2) ruminal supplementation (250 g/d casein); 3) ruminal plus abomasal supplementation (125 g/d casein in the rumen and 125 g/d in the abomasum); and 4) abomasal supplementation (250 g/d casein). Supplements and hay were provided twice per day at 0600 h and 1800 h. The animals were fed with Tifton-85 hay (9.9% CP; 71.5% NDFap) for ad libitum intake. Each period lasted 20 d, comprising 15 d of adaptation and 6 d for sampling. On d 16 through 19 of each period, eight spot samples of abomasal digesta and feces were collected, oven-dried, composited and subsequently analyzed. On d 20 total urine collection was performed. On d 21 blood samples and ruminal fluid were taken every 6 h (beginning at 0600 h) and composited on a daily basis. Supplementation increased ($P < 0.10$) N intake, N total digestibility, N balance, ruminal ammonia-N (RAN), serum urea-N (SUN), renal urea clearance (RUC), RUC proportion excreted, and urinary N and urea excretion. However, there were no differences ($P > 0.10$) between sites of supplementation, except for RAN, SUN, RUC, and urinary N and urea excretion which presented a negative linear effect ($P < 0.10$) by the displacement of supplementation rumen to the abomasum. Ruminal N digestibility, microbial N flow, as well as N retained/N intake were not affected by supplementation ($P > 0.10$). Intestinal N digestibility was increased ($P < 0.10$) by supplementation. Moreover, there was a positive linear effect ($P < 0.10$) on N intestinal digestibility when supplement was changed from the rumen to the abomasum. Fecal N excretion was not affected ($P > 0.10$) by treatments. These results indicate that protein supplementation either in the rumen or in the abomasum, exerts similar effects on efficiency of N utilization, but with different metabolic events.

Key Words: beef cattle, metabolism, nitrogen

1623 (M337) Effect of Amaferm on digestion of diets containing forages with high or low neutral detergent fiber digestibility. A. B. Chestnut*, J. M. Aldrich, W. Hu, W. B. Fokkink, and H. G. Bateman, *Provimi North America, Brookville, OH.*

Amaferm (AF), an extract obtained from fermenting *Aspergillus oryzae*, has been reported to stimulate fiber degrading ruminal fungi and bacteria. The objective of this study was to measure effects of AF on fermentation of typical lactation dairy cow rations containing forages with high NDF digestibility (NDFd) or low NDFd. Corn silage (CS) and alfalfa haylage (AH) with 30 h NDFd of 66.4 and 41.4% of NDF, respectively, were used as the only forages to formulate a high NDFd ration (HFd). A CS and AH with 30-h NDFd of 51.2 and 34.3% of NDF, respectively, were used as the only forages to formulate a low NDFd ration (LFd). Diets were formulated to contain (DM basis) 16.0% NDF from CS and 8.0% NDF from AH. Corn, soybean meal, urea, blood meal, Megalac and molasses were adjusted to equalize CP, soluble CP, starch, nonfiber carbohydrates and fat between diets. A completely randomized experimental design was used with a 2 × 2 factorial arrangement of diet forage NDFd (high or low) and level of AF (0.0 or 0.06% of DM). Diets were fermented in triplicate in continuous culture fermentors at the Rumen Fermentation Profiling Laboratory, West Virginia University, Morgantown, WV. Data on pH were reduced to daily means for each fermentor. Fermentation data were analyzed using the PROC MIXED of SAS with a repeated-measures model. Fermentor was treated as a random variable. First-order autoregressive structure type was selected as the appropriate covariance structure based on the goodness-of-fit criteria. Digestibility (%) of DM, NDF, and nonstructural carbohydrates (NSC) were, respectively, 67.8, 41.4, and 79.3 for HFd, 66.2, 34.8, and 77.5 for HFd + AF, 62.9, 34.9, and 79.3 for LFd and 65.8, 39.6, and 79.5 for LFd + AF. DM digestibility tended to be more for high NDFd vs. low NDFd treatments ($P = 0.08$). Digestibility of NSC was similar among treatments. Adding AF improved NDF digestion of LFd but reduced NDF digestion of HFd (forage NDFd x AF interaction; $P < 0.01$). Average fermentor pH for HFd, HFd + AF, LFd and LFd + AF were 6.03, 6.08, 6.31 and 6.24, respectively, with a main effect due to forage NDFd observed ($P < 0.01$). Adding AF improved NDF digestion of the LFd diet but not the HFd diet. The difference in response of HFd and LFd diets to AF may be related to differences in fermentor pH.

Key Words: Amaferm, NDF digestion

1624 (M338) Differences in forage utilization between *Bos taurus* and *Bos indicus* steers fed low-quality forage and supplemented soybean meal. M. de Oliveira Franco*[1,2], J. E. Sawyer[3], J. R. Baber[4], N. L. Bell[4], E. Detmann[5], and T. A. Wickersham[4], *[1]Universidade Federal de Viçosa, Dep. of Animal Science, Minas Gerais, Brazil, [2]sponsored by CAPES, Brasília, Brazil, [3]Texas AgriLife Research, College Station, [4]Texas A&M University, College Station, [5]Universidade Federal de Viçosa, Minas Gerais, Brazil.*

Five *Bos taurus* (Angus) and five *Bos indicus* steers (Brahman) fitted with ruminal and duodenal cannulae were used in concurrent 5 × 5 Latin squares to determine effects of protein supplementation with varying levels of low quality forage access. Treatments consisted of a control (CON; no supplement and ad libitum access to hay; 2.8% CP, 83.0% NDF) and four treatments arranged as a 2 × 2 factorial: two levels of hay intake (ad libitum and restricted, 1% of initial BW) and two levels of protein (50 and 100 mg N/kg BW, provided as soybean meal 48.5% CP). Periods were 14 d long, with 7 d adaptation and 7 d of sample collection. Data were analyzed using the PROC MIXED of SAS. Terms in the model included treatment, breed, period and treatment × breed, with steer as a random effect. The repeated statement was used for fermentation responses. There were no significant breed differences or treatment × breed interactions for hay intake, digestion, or ruminal fermentation ($P > 0.05$). Supplementation linearly increased ($P < 0.01$) hay intake, total OM intake, and total digestible OM intake in steers given ad libitum access to hay. Feeding 50 or 100 mg N/kg increased total digestible OM intake 34 and 54%, respectively versus CON. Ruminal N balance decreased linearly ($P < 0.01$) in ad libitum fed steers from 36.6 g/d for CON to -30.1 g/d for 100 mg N/kg, suggesting a net influx of urea into the rumen for CON and net absorption of ammonia from the rumen for 100 mg N/kg. When supplement was provided at 50 mg N/kg steers with ad libitum access to hay had greater ($P < 0.01$) ruminal N balance (11.2 g/d) than restricted steers (-3.6 g/d); however, there was only a tendency ($P = 0.09$) for a difference between ad libitum and restricted steers supplemented 100 mg N/kg. Ruminal ammonia N increased linearly ($P < 0.01$) with increasing protein supplementation and was greater ($P < 0.01$) when hay intake was restricted for both levels of N supplement. Similarly, total VFA concentrations were linearly increased ($P < 0.01$) with increasing supplementation; however, VFA concentrations were lower ($P = 0.03$) for both levels of supplementation when hay intake was restricted rather than ad libitum. These data suggest that the forage utilization response to supplemental protein was similar among the subspecies of cattle.

Key Words: low quality forage, protein, supplementation

1625 (M339) Impact of supplementation during the dry season on performance of young Nellore bulls in the post-weaning phase on pasture in the wet season. I. M. de Oliveira*[1], M. H. Moretti[2], A. D. Moreira[3], J. A. Alves Neto[3], R. M. Fernandes[2], P. H. Gonçalves[4], M. A. P. Alves[4], G. F. Berti[4], G. R. Siqueira[1], and F. D. D. Resende[1], *[1]APTA–Agência Paulista de Tecnologia dos Agronegócios, Colina, Brazil, [2]UNESP-FCAV, Jaboticabal, Brazil, [3]Universidade Estadual Paulista, Jaboticabal, Brazil, [4]Centro Universitário da Fundação Educacional de Barretos, Brazil.*

This study evaluated the impact of nutritional strategies on the performance of young Nellore bulls during the post-weaning phase. The experimental period was divided into dry (July to November 2012) and wet (November 2012 to May 2013) seasons. The design was completely randomized, using 60 young Nellore bulls which were distributed into 12 paddocks (experimental units) formed by *Brachiaria brizantha* pastures (5 animals/lot; 6 lots/treatment). In the summer, the paddocks were subdivided (three from each dry season treatment in each new wet season treatment). In the dry season, the animals were assigned to two treatments: a) protein supplement (1 g/kg of body weight; BW) and b) protein and energy supplement (5 g/kg of BW); in the summer were assigned to two treatments: a) mineral supplement ad libitum and b) protein and energy supplement (5 g/kg of BW). To determine the average daily gain (ADG), the animals were weighed at time zero (onset of the experiment) and subsequently every 28 d after being deprived of feed and liquids for 16 h. The data were analyzed as repeated measures over time using the PROC PROC MIXED of SAS. In the dry season, the protein and energy supplementation provided greater ADG (0.434 kg) as compared with the protein supplement (0.293 kg), resulting in heavier animals at the end of this season (225.38 and 208.87 kg, respectively; $P = 0.093$). In the summer, animals fed the protein and energy supplement gained more weight (0.972 kg/day; $P < 0.0001$) in relation to those fed mineral salt (0.623 kg/day). Although no interaction was found in ADG ($P = 0.4798$) between the nutritional plants of dry and wet seasons, the animals which received protein and energy supplementation in the dry season gained less weight (0.766 kg/day; $P < 0.001$) in comparison with those supplemented with protein (0.830 kg/day); this made it possible, at the end of the summer, to eliminate the difference in BW obtained during the dry season. At the end of the post-weaning phase, the young bulls fed protein and energy supplement in the summer completed the period heavier as compared with those fed mineral salt (286.75 and 261.76 kg, respectively; $P = 0.0045$). Protein and energy supplementation during the dry season had negative impact on the ADG in the summer, and increased the BW of the animals at the end of the dry and wet season by 7 and 9%, respectively.

Key Words: energy, performance, protein

1626 (M340) Use of modulators additives the ruminal fermentation in supplements high intake for finished bovines in pasture. J. A. Alves Neto[1], J. M. B. Benatti[1], M. H. Moretti[1], A. D. Moreira[1], R. C. Silva[1], I. M. de Oliveira*[2], P. H. Gonçalves[3], M. A. P. Alves[3], F. D. D. Resende[2], and G. R. Siqueira[2], *[1]Universidade Estadual Paulista, Jaboticabal, Brazil, [2]Agência Paulista de Tecnologia dos Agronegócios, Colina, Brazil, [3]Centro Universitário da Fundação Educacional de Barretos, Brazil.*

Performance of young grazing cattle has been improved by energy supplementation. Additionally, several antibiotics (monensin, lasalocid) have resulted in a consistent grown response. On the other hand, data concerning the effect of virginiamycin in grazing cattle are scarce. Therefore, 96 Nellore bull (480 ± 28 kg BW) were divided in five treatments with different level of supplement and additives blend (T1 = 0.5% BW, T2 = 2% BW, T3 = 2% BW + virginiamycin (25 ppm), T4 = 2% BW + virginiamycin (25 ppm) + monensin (20 ppm), T5 = 2% BW + virginiamycin (25 ppm) + salinomycin (10 ppm). Continue grazing was practiced in *Panicum maximum* cv. Tanzania pasture during dry-season. We used a randomized block design. Twenty paddock (four/treatment) were used divided two blocks (four bull/paddock). Average daily gain (ADG) was calculated using the initial and final individual live weight divided by the number of experimental days. Animals were slaughter in commercial slaughter room and hot carcass weights were obtained to calculate carcass dressing (CD). Statistic analyzer were determined according Proc Mixed SAS 9.0. Paddocks were used as experimental units. Treatments were considered fixed effect and, block aleatory effect. Treatments effects were tested using the following contrasts: 0.5 vs. 2% BW. Animals supplemented with 2% BW shown higher ADG ($P < 0.01$) and had highest CD when compared treatment 2% BW (1.313 vs. 0.534 and 58.4 vs. 53.9, respectively). The effect of virginiamycin and other treatments with 2% BW were tested using contrasts. There were difference ($P < 0.01$) for liveweight gain between treatments 2% BW + virginiamycin (25 ppm) (1.225 kg/d) and 2% BW + virginiamycin (25 ppm) + monensin (20 ppm) (1.505 kg/d), However, 2% BW and 2% BW + virginiamycin (25 ppm) + salinomycin (10 ppm) were not statistically different, the ADG for this treatments were 1.229 kg/d and 1.296 kg/d, respectively. Animals supplemented with virginiamycin ($P < 0.01$) had the highest carcass dressing (59.2) when compared with treatment 2% BW (57.8). Contrast with other treatments not shown statistic difference, achieved 58.7 and 58.0 for treatments 2% BW + virginiamycin (25 ppm) + monensin (20 ppm) and 2% BW + virginiamycin (25 ppm) + salinomycin (10 ppm), respectively. Therefore, increasing supplementation and use of additives may increase animal performance. *Acknowledgment: Phibro Animal Health Corporation.*

Key Words: monensin, pasture, virginiamycin.

1627 (M341) Effects of heights of Marandu pastures and sources of energy supplements on the intake, digestibility of nutrients by young Nellore bulls during the rainy season. A. A. Oliveira[1], M. V. Azenha[*2], S. S. Santana[2], A. L. S. Valente[2], J. P. R. Costa[2], T. T. Berchielli[2], A. C. Ruggieri[2], and R. A. Reis[2], *[1]UNESP, Jaboticabal, Brazil, [2]University of Sao Paulo State, Jaboticabal, Brazil.*

The study was conducted to evaluate the sward heights, and energy supplementation with different sources effects on the forage nutritive value, total DM intake, and digestibility of nutrients by young Nellore bull yearling in pastures of *Urochloa brizantha* cv. Marandu in continuous stocking grazing system during the rainy season. Effects of three sward heights (15, 25, and 35 cm) and three supplements (mineral mixture and two protein-energy supplements, based on corn and other on citrus pulp), were studied. Both energy/protein supplements contained 19.0% of crude protein were supplied at 0.3% of body weight/day. Forage mass, and animal body weight were determined monthly to calculate the forage allowance and the amount of supplement. Experiment was conducted from January to April, at this time forage was sampling by hand plucking methodology to evaluate the nutritive value. Fecal production was estimated using an external marker LIPE; (*Eucalyptus grandis* lignin isolated, purified and enriched). Individual supplement intake was estimated using titanium dioxide (TiO_2) as external marker. Experiment was conducted according to a randomized completely design whit a combination of three pasture heights and three supplements. The average value of NFC was 20.0, 20.0, and 18.9% in pastures of 15, 25, and 35 cm height. There was a linear increase in the levels of NDFap (52.9, 53.6, and 55.9%), and a reduction on the CP levels (16.3, 15.3, and 14.7%) in response to the pasture heights (15, 25, and 35 cm, respectively). Pasture maintained at 15 cm presented highest NPN of total nitrogen, and with 35 cm, showed highest values of N associated to NDF fraction. Intake of DM, OM, and NDF increased linearly in response to sward heights, however diet digestibility decreased. Citrus pulp supplementation as an energy source provided a greatest intake of DM, OM, CP, TDN and also increased the digestibility of DM, OM and CP compared to the others treatments. There was a reduction of NDF digestibility in response to corn supplementation. Swards grazed in lowest height, resulted in lower dry matter intake, but the CP and no fiber carbohydrate intake did not differ among heights, due to the greater proportion of these nutrients in the lowest pastures. It was concluded that swards grazed at lowest height provided forage with better nutritive value. Citrus pulp utilization as a source of energy of supplement increased the intake and digestibility of nutrients.

Key Words: beef cattle, citrus pulp, digestibility, tropical grass

1628 (M342) Within laboratory repeatability of the in situ nylon bag method. H. V. Laar* and J. Doorenbos*, Nutreco R&D, Boxmeer, Netherlands.*

The in situ nylon bag method is the basis of rumen degradation parameters for most feed evaluation models. In our laboratory, over a period of 10 yr all in situ rumen incubations contained a standard sample to study within laboratory repeatability. For raw materials (RM) the standard was a mix of corn, soybean meal and grass meal (1:1:1) to represent starch, crude protein (CP) and fiber fermentation, analyzed in 21 runs. For forage standards were two sequential grass (GS) and corn silages (CS) analyzed in 12 and 11 runs. Approximately 5 g of DM was weighed into 9x18-cm (inner size) nylon bags (40 µm pore size, 30% open surface, Radiometer, The Netherlands). Two or three bags were incubated in the rumen of three lactating fistulated dairy cows at eight time points (up to 336 h). After incubation bags were washed in a washing machine, along with four non-incubated bags per sample (0 h). Samples were pooled over cows by incubation time and analyzed for dry matter (DM), CP, starch and NDF. For each component, washable (W) and undegradable (U) fraction were equated to 0-h loss and 336-h residue. Degradation rate (k_d) was estimated by NLIN procedure of SAS. Effective degradability (ED) was calculated as $ED = W + (100\text{-}W\text{-}U)*(k_d/(k_d+k_p))$ with a k_p (*P*assage rate) of 0.06 for raw material and 0.045 forage standards. Coefficient of variation (CV) was used as measure of repeatability. For the forages CV was based on pooled variation and mean of both standards. Table 1628 shows the CV for ED of various components in RM, GS and CS. CV for NDF is numerically highest for all feeds. For RM, CV of DM is lowest, whereas for GS and CS, CV of CP and starch is lowest. For most components within feedstuff, CV of W, U and k_d(results not shown) was higher than that of ED. These results show that the lowest values for within laboratory repeatability of the in situ nylon bag method are in the range considered poor for analytical laboratory measurements, whereas repeatability values found for NDF are extremely high.

Key Words: In situ, repeatability, fermentation

Table 1628. Coefficients of variation (%) for effective degradation of chemical components of feedstuffs

CV% of ED	Raw Material	Grass Silage	Corn Silage
DM	3.9	5.0	12.2
CP	8.9	3.7	5.6
Starch	10.5	x	5.2
NDF	13.6	9.6	16.4

1629 (M343) Comparison of fermentation kinetics of four feedstuffs using an in vitro gas production system and the ANKOM gas production system.

J. G. L. Regadas Filho*[1], L. O. Tedeschi[2], M. A. Fonseca[2], and L. F. L. Cavalcanti[3], *[1]Universidade Federal de Viçosa, Brazil, [2]Texas A&M University, College Station, [3]Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.*

The objective of this study was to perform a comparison between two computerized systems that are used to determine the fermentation kinetics of in vitro gas anaerobic incubation of feedstuffs. The evaluated systems were the ANKOM^{RF} Gas Production Systems (aIVGP) and the in vitro anaerobic fermentation system (tIVGP) as used at Texas A&M University. The aIVGP uses a wireless system, while the tIVGP a wired system to collect the measures. Four different samples of ground corn, alfalfa hay, dried distillers grain, and dried forage were used (n = 16). All components of the fermentation were maintained constant between the IVGP systems (sample: 0.20 g to tIVGP and 0.39 g to aIVGP; rumen fluid: 4.0 mL to tIVGP and 7.8 mL to aIVGP; media: 14.0 mL to tIVGP and 27.3 to aIVGP; and bottle volume: 158 mL to tIVGP and 307 mL to aIVGP). After 48-h, the concentrations of methane in the bottle's headspace was collected and analyzed using a gas chromatographer. The solution pH was measured and the profiles of the feedstuffs were interpreted using nonlinear model. The total gas production (ml/100 mg of DM), fractional production rate of gas (h^{-1}), pH of the solution and methane concentrations (µmole/ml of gas) were used to compare the systems. The levels of agreement between the IVGP systems were determined using the coefficient of determination (r^2) between both predictions (X axis = aIVGP and Y axis = tIVGP), bias correction (Cb); concordance correlation coefficient (CCC) and mean bias (MB). The IVGP systems had similar values for total gas production (mean X = 17.70; mean Y = 21.23; r^2 = 0.81; Cb = 0.85; CCC = 0.77; MB = 3.58; P = 0.2165), methane concentration (mean X = 2.15; mean Y = 2.66; r^2 = 0.89; Cb = 0.83; CCC = 0.79; MB = 0.51; P = 0.0787) and solution pH (mean X = 6.35; mean Y = 6.31; r^2 = 0.90; Cb = 0.98; CCC = 0.93; MB = -0.04; P = 0.6480). However, the estimated values of fractional production rate of gas were different (mean X = 0.1255; mean Y = 0.1031; r^2 = 0.44; Cb = 0.79; CCC = 0.52; MB = -0.022; P = 0.0032). The results suggest that both IVGP systems had similar fermentations patterns. The difference in the fractional production rate of gas between these IVGP systems may be due to difference in the headspace gas composition.

Key Words: gas production, headspace, in vitro systems

1630 (M344) The influence of source and quality of water and a water treatment system on the ruminal fermentation and nutrient digestibility of a total mixed ration using an in vitro gas production measurement system.

D. Casper* and I. P. Acharya, *South Dakota State University, Brookings.*

There is a wide range in water quality available in South Dakota and this variation could have an impact on the performance of lactating dairy cows. In addition, little is known regarding water treatment systems influence on ruminal fermentation. This study was to evaluate the water source and a water treatment system on the rate and/or extent of ruminal fermentation and nutrient digestibility. A standard TMR consisting of alfalfa haylage, corn silage, and a grain mix was dried at 55°C and ground through a ultracentrifuge mill having a 1.0-mm screen. One g of ground TMR was placed in a 50-µm dacron bag, heat sealed, and then placed in a 500-mL Ankom Gas Fermentation Bottle (GFB) to measure rate and extent of digestion. Treatments were: Control (C): laboratory distilled water; KCU: water taken from a local SD dairy operation before the water treatment system; KCT: water taken after treatment with H_2O_2 product; and DRTF: Municipal water used at the SDSU Dairy Research & Training Farm. Treatments were replicated four times as individual GFB and study was conducted in four blocks. Rumen fluid was collected from a ruminally cannulated lactating dairy cow fed the same TMR and strained through four layers of cheesecloth. Twenty mL of rumen fluid with 200 mL of buffer prepared from each of the water treatments were added to the GFB. Bottles were incubated in a circulating water bath at 39°C and gas measurements were collected every 5 min for 30 h. At the completion of 30 h fermentations, Dacron bags were removed, rinsed, and dried to calculate dry matter disappearance (DMD) and NDF concentrations to calculate NDF digestibility. The rate of gas production was greater (P < 0.01) for C (distilled lab water) compared to other treatments. (16.4, 9.50, 9.66 and 9.71%/h for C, KCU, KCT, DRTF, respectively). The DMD (82.0, 81.6, 80.8 and 81.6% for C, KCW, KCT, and DRTF, respectively) tended to be lower (P < 0.09) for KCT water compared to C water, with all other treatments being intermediate and similar (P > 0.10). The digestibility of NDF (60.0, 59.0, 58.3, and 59.6% of NDF) was similar (P > 0.10) for all treatments. The quality of water can influence rate of ruminal fermentation and the use of a water treatment system had minimal influence on ruminal fermentation and digestibility.

Key Words: gas production, nutrient digestibility, water quality

1631 (M345) Relationships between dry matter degradation, in vitro gas production and chemical composition of 15 feedstuffs. Y. J. Xu, M. Zhao, and D. P. Bu*, *State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China.*

This study was designed to investigate the relationships of in vitro true digestibility of dry matter (IVTD) and in vitro gas production of feedstuffs. Fifteen ruminant feedstuffs were selected in Xinjiang province in China (corn, corn bran, bran, cottonseed meal, soybean meal, DDGS, urea gelatinized corn protein, corn gluten meal, monosodium glutamate residue, grape seed meal, cottonseed hulls, alfalfa meal, alfalfa hay, corn silage and tomato sauce residue). Gas production, volatile fatty acid (VFA) and IVTD at 24-h incubation were measured. Statistical analysis was performed using the PROC CORR procedure of SAS 9.1. The results revealed that strong negative correlation was observed between neutral detergent fiber (NDF) and IVTD ($r^2 = 0.81$, $P < 0.001$). Positive correlation was observed between non-fibern carbohydrate (NFC) and IVTD ($r^2 = 0.74$, $P < 0.001$). In vitro gas production at 24 h was negatively related with NDF content ($r^2 = 0.54$, $P < 0.05$) and positively related with NFC content ($r^2 = 0.92$, $P < 0.001$). In vitro gas production at 24h was positively related with total VFA production ($r^2 = 0.93$, $P < 0.001$). There was strong positive correlation between NFC content and total VFA production ($r^2 = 0.81$, $P < 0.001$). Therefore, chemical composition of feedstuffs were highly related with in vitro gas production, in vitro true digestibility of dry matter.

Key Words: chemical composition, in vitro gas production, in vitro true digestibility of dry matter

1632 (M346) In vitro gas production and dry matter degradability of a high concentrate diet: influence of exogenous enzymes level. D. López[1,2], J. F. Vázquez-Armijo[1], A. F. Z. M. Salem[3], J. Hernández[2], R. Rojo[*1], and J. Cedillo[1], *[1]Centro Universitario UAEM Temascaltepec, México, [2]Universidad Autónoma de Tamaulipas, Ciudad Victoria, México, [3]Universidad Autónoma del Estado de México, El Cerrillo Piedras Blancas, México.*

This study was conducted to evaluate the influence of an exogenous enzyme mixture on in vitro gas production (GP), in vitro dry matter degradability (DMD), metabolizable energy (ME) and short chain fatty acid (SCFA) production in growing lambs fed a high concentrate diet (219 g/kg CP), made with ground sorghum (550 g/kg), alfalfa hay (150 g/kg), soybean meal (220 g/kg), fishmeal (35 g/kg), salt (20 g/kg) and a mineral/vitamins premix (25 g/kg). ZADO (ENZ) is a powdered, commercially available multi-enzyme feed additive produced from *Ruminococcus flavefaciens*. Four levels of ENZ (i.e., 0, 5, 10, and 20 mg/g DM; or E0, E5, E10 and E20, respectively) were applied directly to the substrate inside the incubation bottles before addition of buffer medium and rumen fluid, and the treatments were assayed by triplicate in three runs for different weeks. Bottles were incubated at 39°C for 96 h. The volume of gas produced was recorded at 2, 4, 6, 8, 10, 12, 24, 48, 72, and 96 h after inoculation. A mathematical model was used for estimate lag time, asymptotic gas production and rate of gas production. DMD was determined at end of incubation by filtration of the residue. ME and SCFA were calculated. Data were analyzed as a randomized design and linear and quadratic effects were calculated at $P < 0.05$. Addition of ENZ linearly increased ($P < 0.05$) GP at 6 (74.5, 81.1, 83.7 and 87.5 mL/g DM) and 96 h (334.1, 336.1, 338.5 and 346.8 mL/g DM) of incubation and tended ($P = 0.08$) to linearly increase GP at 12, 48, and 72 h of incubation. Asymptotic GP (334.7, 336.6, 339.1 and 347.3 mL/g DM) was increased linearly ($P = 0.05$) as the level of ENZ increased and the lag time decreased linearly (2.34, 2.12, 1.78 and 1.73 h) ($P = 0.003$). Concurrently, DMD (709, 809, 820, 843 g/kg, repectively) increased linearly ($P < 0.001$) as the level of ENZ increased, but level of ENZ had no effect on SCFA and ME. Finally, level of ENZ had no influence on rate of gas production. Results suggest that this enzyme preparation has potential to improve efficiency of utilization of high concentrate diets fed to growing lambs.

Key Words: enzymes, degradability, gas production.

1633 (M347) In vitro ruminal fermentation with three sources of inoculum in diets containing *Acrocomia aculeate*. S. L. S. Cabral Filho[*1], L. S. Murata[1], R. A. Mandarino[2], C. Eufrásio de Souza[3], D. Leornadi Migotto[3], F. Lopes da Silva[3], J. Artemio Marin Beltrame[4], and J. H. Bernardes Pereira[3], *[1]University of Brasilia, Brazil, [2]Universidade Federal de Minas Gerais, Brasilia, Brazil, [3]Universidade de Brasília, Brazil, [4]Universidade Federal de Mato Grosso do Sul, Campo Grande, Brazil.*

The aim of this study was to determine the potential of different inoculum sources using in vitro gas production technique. Three different sources of inoculum were used for fermentation of gas production analysis: ruminal liquor from fistulated bovine grazing *Brachiaria brizantha* (LR); extracted from slaughtered pig cecum (CS); and cattle feces (FC) collected from the rectum and diluted with distilled water in 10% base. The substrate consisted in three diets content 100% of *Acrocomia aculeate* pulp (AA), 20% AA pulp + 80% of basal diet (20AA) and 10% AA pulp + 90% of basal diet. The basal diet was composed by soy bean meal and corn grains to attempt pig growth requirements. The cumulative volume of gas produced was measured at 0, 3, 6, 9, 12, 16, 24, 48, 72, and 96 h after incubation. The mathematical model used was described by France et al. (1993). The experimental design was one completely randomized blocks in factorial arrange-

ment with eight repetitions (8x3x3). All inoculums showed fermentative capacity and the time of colonization in each trial was lower ($P < 0.05$) for CS followed by LR and FC, was 2.5, 3.2 and 3.7 h, respectively. The substrate with higher potential of gas production was 20AA and presented lower value for FC (205.93 mL) and the difference between LR and CS ($P < 0.05$) (265.05 mL and 299.23 mL). The rates for gas production were: AAxCS, AAxFR, AAxLR (00014 mL.-1h, 0015 mL.-1h and 0028 mL.-1h), 10AAxLR, 10AAxCS, 10AAxFR (00276 mL.-1h, 00410 mL.-1h and 00437 mL.-1h) and 20AAxFR, 20AAxLR, 20AAxCS (00351 mL.-1h, 00365 mL.-1h and 00432 mL.-1h) showed no statistical difference $P > 0.05$). As a conclusion the CS inoculums can be used for the evaluation of gas production.

Key Words: gas production, alternative feed, biogas

1634 (M348) Relationship of protein structural conformation to protein functional property, buffer and water solubility, rumen digestive behaviors, and intestinal availability of common feeds in ruminants. Q. Peng[1,2], N. A. Khan[1], Z. Wang[2], X. Huang[*1], and P. Yu[1], *[1]University of Saskatchewan, Saskatoon, Canada, [2]Sichuan Agriculture University, Sichuan, China*.

The objectives of this study were to determine the relationship between the intrinsic molecular structures of protein feeds and their protein solubility, and rumen and intestinal digestibility in dairy cattle. The feeds investigated were barley, corn, oat, wheat, lentil, peas, canola meal, expeller meal (extruded canola meal), soybean meal, mill feeds (pelleted byproducts from cereal grains), lantic sugar beet pulp, blood meal and meat meal. The protein molecular structure makeup of the feeds was revealed using attenuated total reflectance-Fourier transform infrared molecular spectroscopy (ATR-FTIR). The spectral data on unique bands such as amid I, amide II, and protein secondary structures such as α-helix and β sheet and their ratios were analyzed for differences in intrinsic molecular structures. Moreover, multivariate analysis, agglomerative hierarchical cluster analysis and principal component analysis were computed on the molecular spectral data to distinguish the overall differences in intrinsic molecular structures among the feeds. The protein functional property, solubility, rumen and intestinal digestibility were determined directly using dairy cattle. The PROC MIXED of SAS was used to analyze the univariate spectra data, water-and buffer-based protein solubility, rumen and intestinal protein digestibility. Pearson correlation coefficients between the protein spectral data and protein digestibility were computed using the PROC CORR procedure. A stepwise multiple regression procedure of SAS was performed to determine which of the protein molecular structural features could be used to estimate protein solubility, degradability and digestibility of the prairie feeds. The stepwise option was used with variable selection criteria: SLENTRY = 0.05, SLSTAY = 0.05. The variance inflation factor (VIF) option was used to detect and avoid collinearity among the independent variables. The results showed a large variation in water-and buffer-based protein solubility; ruminal, intestinal and total protein digestibility; and in the inherent structure makeup of protein among the feeds. The protein structural conformation in terms of amide I-and II and protein secondary structures (α-helix and β sheet) were strongly correlated with protein solubility, and ruminal and intestinal digestibility in dairy cattle. The protein structure spectral parameters of amid II area and β sheet height could be used to predict protein intestinal and total digestible content of prairie feeds in dairy cattle. In conclusion, this study report a novel data on protein molecular structure and showed that protein structural makeup was associated with protein nutritional value and digestive behavior in dairy cattle.

Key Words: protein molecular structure, molecular spectroscopy, nutrient availability, metabolic characteristics of protein, ruminants

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1635 (M349) Carbohydrate-protein matrix structure impacts protein and other primary nutrient digestion in common prairie feeds with different soluble and insoluble fractions. Q. Peng[1,2], X. Huang[*1], Z. Wang[2], and P. Yu[1], *[1]University of Saskatchewan, Saskatoon, Canada, [2]Sichuan Agriculture University, China.*

An experiment was conducted to investigate the relationship of carbohydrates molecular spectral characteristics to rumen degradability of primary nutrients in Prairie feeds in dairy cattle. In total, 12 different types of feeds were selected, each type of feed was from three different source with total 37 samples. Six types of them were energy-sourced feeds and the others were protein-sourced feeds. These feeds included various barley, corn, oat, wheat, lentil, peas, canola meal, expeller meal (extruded canola meal), soybean meal, mill feeds (*P*elleted byproducts from cereal grains), lantic sugar beet pulp, blood meal, meat meal etc. The carbohydrates molecular spectral intensity of various functional groups were collected using Fourier transform infrared attenuated total reflectance (ATR-FT/IR) spectroscopy. In the in situ study, the results showed that the rumen digestibility and digestible fractions of primary nutrients (DM, OM, NCP, and CP) were significantly different ($P < 0.05$) among the feeds. The spectral bands features were significantly different ($P < 0.05$) among the feeds. Spectral intensities of A_Cell, H_1415 and H_1370 were weakly positively correlated with in situ rumen digestibility and digestible fractions of DM, OM and NCP. Spectral intensities of H_1150, H_1015, A_1, and A_3 were weakly negatively associated with in situ rumen degradation of CP. Spectral intensities of A_1240 and H_1240, mainly associated with cellulosic compounds, were correlated with rumen CP degradation. The multiple regression analysis demonstrated that the spectral intensities of A_3 and H_1415

played the most important role and could be used as a potential tool to predict rumen protein degradation of feeds in dairy cattle. In conclusion, this study showed that the carbohydrates as a whole have an effect on protein rumen degradation, rather than cellulose alone, indicating carbohydrate-protein matrix structure impact protein utilization in dairy cattle. The non-invasive molecular spectral technique (ATR-FT/IR) could be used as a rapid potential tool to predict rumen protein degradation of feedstuffs by using molecular spectral bands intensities in carbohydrate fingerprint region.

Key Words: carbohydrate-protein matrix structure, rumen degradability, molecular spectral bands

1636 (M350) Performance and dry matter digestibility of finishing lambs fed diets with ground canola grains. N. I. Ortega-Alvarez[1], G. Buendia-Rodriguez[2], J. A. Cuaron-Ibarguengoytia[2], G. D. Mendoza-Martinez[3], and S. S. Gonzalez-Muñoz[*4], *[1]Universidad Nacional Autonoma de México, México D.F., [2]CENIDFyMA INIFAP, Queretaro, México, [3]Universidad Autonoma Metropolitana, Unidad Xochimilco, México D.F., [4]Colegio de Postgraduados, Montecillo, Estado de México.*

Canola seeds have 42–43% EE, 20% CP, and they can be used as a source of protein and energy for ruminants. The objective of this experiment was to evaluate the effect of ground canola grain (GCG) or canola meal (CM) and canola oilseed (CO) added to a concentrate diet (14.59% CP and 2.8 Mcal ME/kg DM) on finishing 21 Pelibuey x Texel lambs (32.09 ± 5.48 kg initial BW) housed in metabolic cages during 42 d. The experimental design was completely randomized with three treatments: T0: 4.6% CM, 67% sorghum grain, 19.5% alfalfa hay; T1: 7.5% GCG, 63.5% sorghum grain, 19.5% alfalfa hay; T2: 4.5% CM, 3% CO, 64% sorghum grain, 19.5% alfalfa hay (all diets contained 5% cornstalk, 2% cane molasses, 1% urea, 1% premix); and seven replications (lambs) per treatment. Variables were average daily gain (ADG, g), daily DM intake (DDMI, g), feed conversion (FC), carcass yield (CY, %) and DM digestibility (DMD, %). Data were analyzed using PROC MIXED (SAS v 9.0) and treatment means were compared with Tukey test ($P \leq 0.05$). Addition of ground canola grain to the diet did not change ADG (321, 382, 391 g; $P = 0.14$), DDMI (1796, 1671, 1790 g; $P = 0.54$), FC (5.75, 4.47, 4.64; $P = 0.09$), CY (54.13, 52.15, 52.16%; $P = 0.45$) and DMD (74.14, 78.80, 73.87%; $P = 0.13$). Since there were no differences among treatments, it may be concluded that ground canola grain can be used in diets for finishing lambs.

Key Words: canola grain, performance and digestibility, lambs

1637 (M351) Ruminal pH and epithelial function as affected by increasing compound feed supply in growing Holstein heifers. A. Navarro-Villa[1], M. A. Steele[*2], J. A. Metcalf[2], and J. Martin Tereso[1], *[1]Nutreco Research, and Development, Boxmeer, Netherlands, [2]Nutreco Canada Agresearch, Guelph, ON.*

Adaptation to high-concentrate diets involve changes in ruminal milieu and epithelium that remain largely undescribed. Changes in ruminal pH and epithelial function were studied by gradually introducing compound feed (CF)(from 0 to 8kg/d as-fed; Δ+0.5kg/d) in the diet of four fistulated Holstein heifers (8 ± 0.*32* mo of age) with ad libitum access to chopped barley straw. Loggers placed in the ventral rumen continuously monitored pH over 16 d. Cumulative time (min/d) spent below pH cut-off points was calculated for each animal and fitted to a logistic curve (AlZahal et al., 2007), where the slope (β_0; indication of daily pH range) and inflection point (β_1; median pH value) were calculated. Linear correlation between these parameters and CF supply was calculated. Rumen papillae samples were biopsied for RNA extraction and subsequent gene expression analyses when cattle consumed 0, 4, and 8kg of CF/d. Total DM intake was 5.8 ± 0.76, 6.9 ± 1.08 and 8.9 ± 0.71kg/d and straw intake 4.0 ± 0.76, 3.3 ± 1.08 and 1.7 ± 0.71kg/d for CF levels of 0, 4, and 8kg/d, respectively. The daily minimum pH was 6.4 ± 0.19, 6.0 ± 0.12 and 5.8 ± 0.17 at 0, 4, and 8kg/d CF, respectively. In contrast, no changes in daily maximum pH (from 7.3 ± 0.17 to 7.3 ± 0.31) and subtle decreases in daily mean pH (from 6.9 ± 0.1 to 6.7 ± 0.24) were observed with increasing CF intake. The slope of the logistic curve decreased ($P < 0.05$) as the intake of CF increased resulting in 8.7 ± 0.69, 6.6 ± 0.69 and 2.1 ± 0.69 for 0, 4, and 8kg CF/d, respectively. The inflection point decreased ($P < 0.05$) with CF supply but was not affected by CF dose (6.8 ± 0.13, 6.6 ± 0.11 and 6.3 ± 0.21 for 0, 4, and 8 kg CF/d, respectively). Slope correlated better to CF intake [$\beta_0 = 9.5(\pm 0.48)$-$0.6(\pm 0.10)\times$CF(kg); $R^2 = 39$] than inflection point [$\beta_1 = 6.8(\pm 0.06)$-$0.008(\pm 0.010)\times$CF(kg); $R^2 = 0.01$]. The relative mRNA expression of tight junction genes claudin1 (CLDN1) and claudin4 (CLDN4) were downregulated ($P < 0.05$) by 0.77 ± 0.03 and 0.85 ± 0.06-fold between 0 and 4 kg CF inclusion, respectively. Moreover, the relative mRNA expression from 0 to 4 and 0 to 8 kg CF supply was up-regulated ($P < 0.05$) for putative anion transporter 1 (PAT1) (1.25 ± 0.07; 1.39 ± 0.15) and carbonic anhydrase 1 (CA1) (1.20 ± 0.09; 1.30 ± 0.20). Based on the results of this study, adaptation to high-concentrate diets was associated more extreme fluctuations in rumen pH rather than obvious declines in average ruminal daily pH. In addition, adaption to high-concentrate diets involved changes in gene expression of key transport (PAT1), metabolic (CA1) and tight junction genes (CLDN1 and CLDN4) in the epithelium.

Key Words: rumen pH, adaptation, gene expression

1638 (M352) Metabolic characteristics of grazing Nellore bulls receiving concentrated supplementation with additives. J. A. C. Lima[*1,2], H. J. Fernandes[2], E. P. Rosa[2], L. S. Caramalac[2], K. A. Silveira[2], G. C. Silva[2], B. D. D'auria[2], and A. Aguiar[3], *[1]Federal University of Viçosa, Brazil, [2]State University of Mato Grosso do Sul, Aquidauana, Brazil, [3]University of Florida, Gainesville.*

The objective of this study was to evaluate the effect of a commercial concentrate supplement with additives in the metabolic characteristics of grazing bulls, during the dry/rainy transition season in Aquidauana–MS, Brazil. Twelve Nellore bulls (initial body weight of 370 ± 15 kg) were randomly assigned to twelve *Brachiaria decumbens* Stapf pastures (1.0-ha/pasture; one bull/pasture) on a completely randomized design. Treatments were: 1) concentrate supplement Lipomax with homeopathic additives (Convert H, Sodo 100, Figotonus) and Virginiamicina (Lipomax treatment), and 2) concentrate supplement with a similar protein content (18% CP), and without additives (Control treatment). Animals were feed daily at rate of 0.5% of the animal's body weight. After 53 d, when the animals achieved body weight of 426 ± 27.3 kg, urine "spot" and blood samples of the animals were collected, 4 h after the concentrate supplement was offered. Urine samples were analyzed for creatinine (for daily urine total production estimative), N-urea and total-N, and blood samples for serum urea. A significance level of 5% was adopted. Serum urea, and urine N-urea and total-N excretion of the grazing animals showed no difference ($P > 0.05$) when the additives were used in the concentrate supplementation (Table 1638). The low levels of these metabolic parameters for grazing animals indicated an efficient use of the diet metabolizable protein, and the use of additives could not increase this efficiency.

Key Words: grazing bulls, protein metabolism, tropical environment

Table 1638. Parameters of protein metabolism of Nellore bulls grazing brachiaria grass and receiving concentrated supplement with or without additives

	Treatments			
Item	Control	Lipomax	CV (%)	P-value
URbl[1] (md/dl)	15.1	14.7	10.3	0.690
Nururine[2] (g/d)	35.9	33.0	28.6	0.622
Ntotur[3] (g/d)	45.9	55.1	24.8	0.231

[1] URbl is the blood urea, mg/dl.

[2] Nururine is the N-urea in urine, g/d.

[3] Ntotur is the N total in urine, g/d.

1639 (M353) Productive parameters, metabolic and economic viability of dairy cows supplemented with different levels of urea in diets based on sugarcane. R. C. D. Souza[*1], R. B. Reis[2], F. C. F. Lopes[3], J. M. Leão[2], and M. H. F. Mourthé[4], *[1]PUC Minas, Betim, Brazil, [2]UFMG, Belo Horizonte, Brazil, [3]Embrapa Gado de Leite, Juiz de Fora, Brazil, [4]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, Brazil.*

Sugarcane has been recommended for dairy farms that utilize low-yielding cows, used in to feeding regimes that do not seek to obtain high lactating performance per animal. The utilization of sugarcane and other feedstuffs, should be based on dietary formulations that incorporate nutritional-model recommendations of practical use (NRC, 2001). Sugarcane was also considered adequate for dairy cattle producing 20 kg of milk per day. The sugarcane yield support potential, in balanced diets, must be defined more precisely to allow recommendations to be specifically targeted. No scientific data exist to support the use of sugarcane in diets formulated for high-performance lactating animals. Sugarcane has been used for animals of higher production due to its qualities, among them, the low cost of dry matter. However, the appropriate level of urea in to add to cane sugar diets feed to high production animal is still questionable. The objective of this study was to evaluate feed intake, nutrient digestibility, feed efficiency, production and milk composition, metabolic parameters and the economic viability of lactating cows fed diets based on sugarcane supplemented with increasing levels of urea: sulfate on dry matter basis (0, 0.5 and 1.0%). Twelve multiparous cows and six primiparous Holstein and Holstein x Gir, with 83 + 7 d of lactation, average milk yield of 21.3 ± 0.8 kg/d, average body weight of 580 + 18.3 kg, fed with total mixed ration 50:50, assigned to reversion assay type switch-back, 3 × 3. Cows fed the diet with 1.0% urea had lower ($P < 0.05$) dry matter intake (DMI) and organic matter intake (OMI), but feed efficiency higher on this diet. DMI, OMI and feed efficiency was 19.64, 19.66 and 18.33 kg/d, 18.24, 18.31 and 17.03 kg/d and 1.14, 1.17 and 1.71 kg/kg, respectively for diets containing 0.0, 0.5, and 1.0% of urea. There was no effect of diet

on nutrient digestibility, milk yield, milk composition and on plasma concentration of urea, glucose and insulin ($P > 0.05$). All diets had a positive balance if considered only cost with food, however the 1% urea diet showed the best outcome per cow. For dairy cows, with an average milk yield of 22 kg/d, sugarcane supplemented with 1% urea in green matter basis despite decreasing the dry matter intake, may be used, without causing any adverse effect on production and metabolic and improve parameters of cost.

Key Words: sugarcane, urea, productive parameters.

1640 (M354) Chia seed supplementation increases ruminal propionate concentration in alfalfa hay based diets evaluated in a dual-flow continuous culture system. J. Bunkers*, E. Marostegan de Paula, L. Galoro da Silva, T. Shenkoru, Y. L. Yeh, B. Amorati, D. Holcombe, and A. Faciola, *University of Nevada, Reno.*

Chia seed (CS) and flaxseed (FS) are rich in omega-3 fatty acids which may provide health benefits when added to animals' diets. However, data on the effects of CS supplementation on ruminal metabolism is scarce. The objective of this experiment was to determine nutrient digestibility, rumen fermentation characteristics, microbial protein synthesis, and long-chain fatty acids flow of supplemented alfalfa hay (AH) diet with either CS or FS. Diets were randomly assigned to six dual-flow continuous culture fermenters (1200 to 1250 mL) in a replicated 3 × 3 Latin square arrangement with three 10-d experimental periods consisted of 7 d for diet adaptation and 3 d for sample collection. Fermenters were fed a total of 72 g of DM/d equally divided in four portions. Diets consisted of (DM basis) 95% AH supplemented with: 5% Megalac (Diet A), 5% FS (Diet B), and 5% CS (Diet C). Liquid and solid dilution rates were adjusted daily to 10%/h and 5%/h, respectively. A sample of 500mL from each fermenter was taken on d 8, 9, and 10. Two subsamples of 10 mL were filtered through two layers of cheesecloth, were preserved with 0.2mL of 50% sulfuric acid and centrifuged for ruminal NH_3 and VFA analysis. Statistical analyses were performed using the GLM procedure in SAS. Ruminal metabolism data are presented in the table. Supplementing CS increased the molar proportion of propionate and decreased Acetate:Propionate ratio. There were no differences among treatments for ruminal NH_3 concentration, total VFA concentration, and molar proportions of acetate, butyrate, and branched-chain VFA. Results from this experiment indicate that CS supplementation may change ruminal metabolism by increasing ruminal propionate concentration which may be energetically beneficial for glucose synthesis in ruminants.

Key Words: dual-flow continuous culture, chia seed, flaxseed

Table 1640.

	Diet Composition %DM				
	Megalac	Flaxseed	Chia seed	SEM	*P*-Value
EE	5.6	5.6	5.6		
CP	18.5	19.2	19.4		
NDF	40.9	41.7	42.5		
NH_3–N, mg/dL	5.34	5.38	6.34	0.58	0.46
Total VFA, mmol	125.61	119.12	116.41	5.02	0.48

1641 (M355) Analysis of rumen motility patterns using a wireless telemetry system to characterize bovine reticuloruminal contractions. A. M. Egert*[1], K. R. McLeod[1], J. L. Klotz[2], and D. L. Harmon[1], *[1]University of Kentucky, Lexington, [2]USDA-ARS, FAPRU, Lexington, KY.*

The objective of this study was to characterize rumen motility patterns of cattle fed once daily. Eight ruminally-cannulated Holstein steers (BW = 321 ± 11 kg) were fed alfalfa cubes once daily at 1.5 × NE_m top-dressed with a TM-salt pre-mix. Three 24-h collection periods were conducted and each commenced immediately following feeding. A wireless telemetry system (emkaPACK*4G* telemetry system, emka TECHNOLOGIES USA, Falls Church, VA) was used to monitor real-time pressure changes in the rumen. Pressure transducers and transmitters were housed in a plastic container with screw-on lid that served as the cannula cap. A weighted (300 g), water-filled (1 L), balloon-tipped catheter was connected to the transducer through an adaptor and placed below the mat in the ventral sac of the rumen. Data were recorded and stored using iox2 software (iox 2.9.4.27, emka TECHNOLOGIES USA) which utilized a rhythmic analyzer to analyze the raw rumen pressure data, identify ruminal contractions, and calculate the following parameters for each contraction: baseline pressure, peak pressure, amplitude, frequency, time to peak, relaxation time, duration, and area under the curve. Mean results were calculated for each parameter (Table 1641). All parameters were affected ($P < 0.0001$) by animal and hour. Baseline and peak pressure of contractions increased through 14 h post-feeding, which may have been due to animals laying down more often. Amplitude of ruminal contractions was greatest the first 5 h post-feeding and then decreased quickly. Frequency, duration, and area decreased throughout the collection period, but increased shortly before the next feeding. Mean water intakes for the first and second 12 h post-feeding were 35.5 ± 2.19 L and 0.92 ± 0.26 L, respectively. These data demonstrate that wireless telemetry can be used to non-invasively monitor rumen motility patterns in freely moving steers. Feeding management impacts the values obtained and must be considered when designing experiments.

Key Words: forestomach, motility, rumen pressure

Table 1641. Means values and range between animals for rumen contraction variables measured

Item, units	Mean[1]	SEM[2]	Range[3]
Baseline, mmHg	22.99	2.35	8.35
Peak, mmHg	30.28	2.47	8.26
Amplitude, mmHg	7.29	0.40	1.04
Frequency, contractions/min	2.87	0.17	0.83
Time to peak, s	4.06	0.33	1.18
Relaxation time, s	5.22	0.47	1.14
Duration, s	9.28	0.62	1.74
Area, mmHg*s	30.41	2.43	6.35

[1] Mean = overall mean
[2] SEM = standard error of the mean, $n = 8$
[3] Range = range of means between the 8 animals

1642 (M356) Use of grouped samples of orts does not compromise feed intake data in studies of confined cattle. D. Zanetti[1], S. C. Valadares Filho*[1], M. V. C. Pacheco[1], L. F. Prados[1], E. Detmann[1], L. A. Godoi[1], F. C. Rodrigues[1], R. C. D. O. Ribeiro[2], J. M. D. Silva Júnior[1], and S. A. Santos[5], *[1]Universidade Federal de Viçosa, Minas Gerais, Brazil, [2]Universidade Federal de Minas Gerais, Belo Horizonte, Brazil, [3]Universidade Federal da Bahia, Salvador, Brazil.*

The orts in the feed bunk are commonly analyzed as composited samples, which are collected within periods of 7 or 28 d for each animal. In this context, the use of only one grouped sample of orts per animal for the entire experimental period may reduce the labor and costs of laboratorial analysis. Therefore, this study aimed to compare samples of orts collected weekly with a grouped sample collected within 12 wk of feedlot. A total of 24 castrated cattle with average body weight of 397.3 kg were fed diets with 70:30 or 40:60 roughage:concentrate ratio using sugarcane as the only roughage source. Diets were provided, sampled and adjusted daily so the orts remained around 5% of the total offered. Orts were sampled daily and proportionally grouped weekly. Sample of orts were analyzed individually or as grouped samples, formed by grouping 12-wk samples of the experiment according to the proportion of orts in the feed bunk. Comparisons of nutrient intake were evaluated using the linear regression model of the values observed for the two sampling methods and the simultaneous hypothesis were tested as it follows: H_o: $\beta 0 = 0$ e $\beta 1 = 1$. Sampling methods were considered similar when the null hypothesis was not rejected. All the statistical analysis was performed by using SAS and differences were considered at $\alpha = 0.05$. The use of these diets allowed a great variation in the composition of orts where the levels of DM ranged from 25.06 to 82.21%, CP ranged from 4.01 to 14.11%, and NDF ranged from 32.52 to 77.06%. Comparisons of the estimates of nutrient intake are presented in Table 1642. In all cases, $H_0$was not rejected ($P > 0.05$) which indicates that dry matter and nutrient intake does not vary comparing orts collected weekly of a composite sample of 12 wk. We conclude that the use of a single sample of orts in the period of 12 wk for each animal is viable and reduces the time and cost of chemical analyzes.

Key Words: feedlot, nutrient intake, orts

Table 1642. Comparisons of estimates of nutrient intake (kg/day)

Treatment	Intake	Average	max	min
Weekly	DM	8.85 ± 1.84	12.58	5.87
	OM[1]	8.42 ± 1.74	11.95	5.60
	CP	1.11 ± 0.23	1.57	0.73
	NDF	3.99 ± 0.73	5.48	2.76
Grouped Samples	DM	8.84 ± 1.84	12.46	5.85
	OM	8.41 ± 1.74	11.84	5.58
	CP	1.10 ± 0.22	1.56	0.73
	NDF	4.00 ± 0.74	5.45	2.73

[1]Organic Matter

1643 (M357) Three dimensional imaging of rumen tissue for morphometric analysis using micro-computed tomography. M. A. Steele*[1], F. Garcia[2], M. Lowerison[3], K. Gordon[2], J. A. Metcalf[1], and M. Hurtig[2], *[1]Nutreco Canada AgResearch, Guelph, ON, [2]University of Guelph, ON, Canada, [3]University of Calgary, AB, Canada.*

Rumen development in calves has been evaluated microscopically by measuring papillae height, width and density. Although common in the literature, there are disadvantages such as large variations in rumen papillae size and shape, small numbers of total papillae being measured and the time required. The objective of this study was to develop a more effective technique for assessing rumen papillae using micro-computed tomography (micro-CT) and to compare this technique with microscopy. Rumen tissue was collected from the ventral sac of 20 bull calves at 55 d of age, immediately fixed in 10% Neutral Buffered Formalin for 48 h and stored in 70% ethanol at 4°C before the contrast enhancement. After evaluation of contrast enhancement protocols which included phosphotungstic acid, osmium tetroxide, and mercury chloride it was determined that mercury provided the most pronounced contrast for accurate micro-computed tomography imaging based on relatively density of the papillae. A 1 cm^2 tissue section from the ventral sac of all bull calves was tensioned on rapid prototype curved plastic holders and imaged at 45-µm resolution for 56 min using a GE Locus Explore micro-CT. MicroView V2.2 software created a three dimensional model of the entire sample. The height and width of 20 papillae per micro-CT section were measured three dimensionally and compared with measurements of 20 papillae under the light microscope taken from the same region using a mixed model equation with a random effect for calf. The length and width measurements using micro-CT (2.47 ± 0.12mm and 0.55 ± 0.01mm) compared to light microscope (2.96 ± 0.03mm and 0.86 ± 0.01mm) were significantly smaller ($P < 0.0001$). The difference may reflect a more accurate determination in the base of the rumen tissue with micro-CT or the specificity of mercury to bind only intact rumen tissue. The mean number of papillae per cm^2 viewed using micro-CT was 128.5 ± 33.9 with a total surface area of 681.8 ± 112.4 mm^2 and volume of 156.2 ± 33.2 mm^3 per sample. Micro-CT data showed that surface area and volume are positively associated ($P = 0.04$) and that papillae length was negatively associated ($P < 0.001$) with papillae per cm^2 and positively associated ($P = 0.02$) with total volume of tissue section as determined by Pearson Correlations. This study represents the first time that micro-CT has been being used to assess morphology of gastrointestinal tissue. Micro-CT has the potential to improve the accuracy and efficiency of rumen tissue measurements however more standardization of each factor involved in tissue preparation and imaging is required.

Key Words: rumen, morphology, development

1644 (M358) Kinetics of gas production of soybean meal, cotton seed meal and fish meal is affected using different zeolites. F. Kafilzadeh, M. Karimi Zandi, and G. Taasoli*, *Razi University, Kermanshah, Iran.*

An in vitro experiment was performed to study the effect of four types of zeolites (Clinoptilolite 1, Clinoptilolite 2, Clinoptilolite A and Heulandites) on kinetics of gas production of three different protein sources (soybean meal, cotton seed meal and fish meal). The cumulative gas production was measured at 2, 6, 10, 14, 18, 22, 24, and 48 h of incubation using a pressure transducer. Each sample was incubated in three replicates. The incubation inoculum was prepared by diluting the rumen liquor with a buffer solution (Tilley and Terry, 1963). Fifteen mL of buffered rumen fluid (20% rumen fluid + 80% buffer solution) prepared and were anaerobically dispensed in each tube at 39°C. All the tubes were crimped, placed in an incubatorat 39°C, and shaken at regular times. A factorial experiment within completely randomized design (CRD) was performed for data on gas production parameters from different protein sources and difference zeolites. All analyses were done on MSTATC program. The result of in vitro gas production showed that there were significant differences between total gas production and lag time of different protein sources ($P < 0.05$). Total gas production was affected by different zeolites ($P < 0.05$). A significant effect of feed × zeolite was observed for the rate at which gas was produced (c) ($P < 0.05$). The mean value for total gas production, lag time and the rate of gas production were 15.68 (ml/125 mg DM), 0.06 (%/h) and 0.31 (h), respectively. Fish meal, among the different protein sources and Clinoptilolite 2 among the different zeolites resulted in the highest gas production rate (0.08). Heulandites produced the highest cumulative gas production (17.41ml/125mg DM) as compared to the other zeolites.

Key Words: gas production, zeolites, protein sources

1645 (M359) Effects of zilpaterol hydrochloride on feedlot performance and carcass characteristics of hair-breed ram lambs. A. Mendoza-García[1], R. Rojo-Rubio[*2], U. Macias-Cruz[3], L. Avendaño-Reyes[4], A. F. Z. M. Salem[5], M. A. Jaime[1], and J. F. Vázquez-Armijo[1], *[1]Universidad Autónoma del Estado de México, Temascaltepec, [2]Universidad Autonoma del Estado de México, Temascaltepec, [3]Universidad Autonoma de Baja California, Mexicali, México, [4]Universidad Autonoma de Baja California, Calexico, [5]Universidad Autónoma del Estado de México, El Cerrillo Piedras Blancas.*

Twenty-one Dorper × Pelibuey croosbred ram lambs (39.01 ± 1.09 kg; 4 mo of age) were individually housed in pens equipped with shade, feed troughs and automatic waterer. Ram lambs were adapted to pens and basal diet, during a 20-d period. One wk before initiation of the experimental phase, lambs were individually weighed, stratified by BW and randomly assigned to treatments under a completely randomized design to evaluate effects of zilpaterol hydrochloride (ZH) levels (ZH; 0, 10, and 20 mg/Lamb daily; to ensure a total intake of ZH, 133.33 g was mixed with 19.1 kg of wheat meal, and 30 g/Lamb daily of mixture was offered to lambs before the morning feeding) on feedlot performance, carcass characteristics, and wholesale cut yield of ram lambs. After a 30-d feeding period, all lambs were harvested. Entire feeding period, ZH increased ($P \leq 0.05$) ADG and tended to increase ($P = 0.076$) feed intake. G:F was not affected ($P = 0.38$). In addition, ZH improved hot carcass weight, cold carcass weight, conformation (ranked 1: bad and 10: excellent), and dressing percent ($P \leq 0.05$). ZH don´t affected ($P \geq 0.05$) KPH fat, but tended ($P = 0.08$) to improved LM area (cm^2). ZH at 10 mg/Lamb dose increased ($P = 0.005$) carcass length (cm), but ZH at 20 mg/Lamb dose showed the highest leg perimeter ($P \leq 0.01$). ZH affected ($P \leq 0.05$) LM pH at 24 h postmortem ($P \leq 0.05$). All non-carcass components were not affected ($P \geq 0.05$) by ZH doses. Leg yield ($P = 0.01$) and plain loin ($P = 0.04$) decreased with ZH and yields of other wholesale cuts were not affected ($P \geq 0.1$). Inclusion of ZH improve some variables of feedlot performance and carcass characteristics of economic importance such as ADG, feed intake and LM area, carcass leg and leg perimeter.

Key Words: β-adrenergic agonist, feedlot sheep, growth rate, carcass characteristics

1646 (M360) Effect of particle size on dry matter intake and ruminal pH in goats fed with alfalfa hay and sorghum silage. D. Esparza[*1], R. Rodriguez[1], G. Veliz[1], C. Meza-Herrera[2], and P. Robles-Trillo[1], *[1]Universidad Autonoma Agraria Antonio Narro, Torreon, México, [2]Universidad Autonoma Chapingo, Unidad Regional Universitaria de Zonas Aridas, Bermejillo, México.*

The aim of this work was to evaluate the effect of particle size on dry matter intake and ruminal pH in Alpine goats. The experiment was designed as a 4 × 4 latin square with eight goats at the end of lactation. Treatments considered a 2 × 2 factorial arrangement; two forage particle lengths of alfalfa hay [short (1 ± 0.03 cm) and long (4 ± 0.05 cm)], combined with two different alfalfa hay and sorghum silage ratio (75:25 or 50:50). The forage:concentrate ratio was 60:40 for all rations. The particle size distribution of the diets was determined with the Penn State Particle Separator using the screen 2 and 3. Each period consisted of 11-d of adaptation stage and 3-d of experimental measurements. Subsequently, diets were exchanged during three periods. Offered food and orts were measured and recorded daily during the last 3 d of each period to calculate food intake. Ruminal fluid was collected on d 14 at 0700, 1100, 1500, 1900, 2300, and 0300 h and ruminal pH was immediately measured. According to our results, alfalfa hay particle

size did not affect voluntary intake (Table 1646), while silage can replace hay without affecting food intake or ruminal pH.

Key Words: goat, particle size, dry matter intake, ruminal pH

Table 1646. Dry matter intake and ruminal pH affected by alfalfa hay particle size

	50:50		75:25			
Diet	Long	Short	Long	Short	SE	*P*- value
DMI	1.39	1.44	1.45	1.53	0.38	NS
Ruminal pH	6.2	6.2	6.2	6.2	0.3	NS

1647 (M361) Milk composition of Murrah buffalo grazing on pasture in the Municipality of Taipu, Rio Grande do Norte, Brazil.

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Brazil produces 27.75 billion liters of milk annually, with 92.3 million L coming from buffalo. There are 2500 establishments registered with the Brazilian Association of Breeders of Buffalo. It is estimated that the country has 2 million buffalo, with 82,000 contributing to milk production. Previous research indicates that buffalo-derived milk has numerically greater fat and total solids when compared to milk from dairy cattle, making it valuable for the dairy industry, especially in the production of mozzarella. The objective of this experiment was to evaluate the milk composition from buffalo within a herd at Tapuio Farm (Taipu, Rio Grande do Norte, Brazil) during the dry season (January to March). Total milk production was measured from 300 multiparous females each d over 1 wk. Samples of milk were collected from each female three times over the same wk. Immediately after collection, samples were sent to the Dep. of Animal Science at the Federal Rural University of Pernambuco for analysis. An overall average was obtained for milk production and composition from the entire herd. The milk composition results are shown in Table 1647 which compares the national average of buffalo, dairy cattle, and the results from this study. The farm's average milk production was 2500 kg/d, with an average individual animal production of 8.3 kg/d. This is above the national average of 7 kg/d for buffalo. However, numerically reduced values were observed for fat and total solids when compared to national averages for buffalo. This may have been due to poor pasture quality, caused by regional drought at the time of sample collection. These results reaffirm the superiority of the milk composition of buffalo compared to dairy cattle. With the improved milk composition of buffalo, it is possible to achieve a 40% yield improvement in the industrialization process when compared to the yield from cattle. This improvement in yield results in increased economic returns to the producer.

Key Words: buffalo, milk composition, yield

Table 1647. A comparison of milk composition between buffalo[1], cattle[1], and buffalo at Farm Tapuio

Nutrient (%)	Buffalo	Cattle	Farm Tapuio
Fat	7.15	3.5	6.42
Protein	4.15	3.6	4.56
Lactose	4.95	4.5	4.55
Total solids	16.86	11.9	16.52

[1] Results reported as a national average (Santos et al., 2001).

1648 (M362) Performance and morphometry of the gastrointestinal tract of goats kept on pasture during the dry period of the semiarid Pernambuco.

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The carcass length, your characteristics and of non-carcass components are directly related to the nutritional composition of the diet. The production of good quality protein also depends on the genotype and the environment in which the animal is held, which points to the importance of the use of supplementation, at the time of low rainfall, which creates food shortages, especially in native pasture, which is characterized by high variation in the chemical composition throughout the year, especially when it comes to semiarid region, Caatinga vegetation, which has its own characteristics, such as loss of leaves and disappearance of native species in the dry season. The experiment aimed to evaluate the endogenous losses in goats kept in grazing unrestricted with and without supplementation, and restricted grazing. Eighteen animals were used without pattern purebred (WPPB), neutered, with average live weight of 16 kg ± 0.22 BW with 90 d of age, undergoing an adjustment period for 15 d. The animals were divided into three treatments: grazing at will without supplementation to slaughter (GWS), grazing at will over supplementation with forage palm + soybean meal (GS) and restricted grazing (RG), with access to pasture during about four h/d, or according to the maintenance of BW. For statistical analysis was used the test F with 5% of probability. A significant difference was observed for slaughter weight ($P = 0.00023$) with higher means for the treatment GS (22.74 BW) when compared with others treatments, however there was no difference between the GWS (18.12 BW) and RG (16 BW) treatments. The same behavior was also observed for weight empty body (18.4 BW, 14.34 BW and 12.60 BW, respectively) ($P = 0.00026$). A significant

difference (P = 0.00965) was observed for rumen/reticulum, omasum, small intestine, and total gastrointestinal tract to the GS did not differing between GWS and RG. WPPB goats supplemented during the dry period had higher values of morphometric gastrointestinal tract in relation to goats kept on pasture only or restricted grazing.

Key Words: goats, growth, pasture

1649 (M363) Effects of replacing alfalfa hay and corn silage with corn straw in diets on milk production and composition of dairy cows. Y. Zhang[1,2,3], N. Zheng[1,2,3], D. P. Bu[3], M. Zhao[3], X. Q. Zhou[3], and J. Wang[*1,2,3], *[1]Ministry of Agriculture–Laboratory of Quality and Safety Risk Assessment for Dairy Products, Beijing, China, [2]Ministry of Agriculture–Milk and Dairy Product Inspection Center, Beijing, China, [3]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China.*

A study was conducted to determine the effects of replacing alfalfa hay and corn silage as the only forage source with corn straw on milk production and composition. Thirty-two primiparous Holstein cows (55 ± 15 d, days in milk) were divided into two groups fed ad libitum a TMR containing either 17.30% alfalfa hay and 18.77% corn silage (control group) or 36.07% corn straw (CS group). The experiment period was 105 d with 14-d adaptation. Cows were fed individually with auto feeding system and food intake was recorded continuously using a computerized monitoring system (RIC system, Insentec B.V., Marknesse, Netherlands). Data were analyzed using the PROC MIXED of SAS (SAS 8.2; SAS Institute Inc., Cary, NC). Dry matter intake (21.35 vs. 17.43 kg/d, $P < 0.01$), crude protein intake (3.84 vs. 2.90 kg/d, $P < 0.01$) and consumption rate (103.25 vs. 68.65 g DM/min) were higher in the control cows, indicating more attractiveness to the cows. Higher milk yield (30.45 vs. 23.12 kg/d, $P < 0.01$), milk protein content (3.66 vs. 3.32%, $P < 0.01$) and yield (1.11 vs. 0.77 kg/d, $P < 0.01$), milk fat yield (1.34 vs. 1.02 kg/d, $P < 0.01$), milk lactose yield (1.47 vs. 1.13 kg/d, $P < 0.01$) were observed in the control cows, whereas milk fat content (4.46 vs. 4.38%, $P = 0.65$), and milk lactose content (4.86 vs. 4.80%, $P = 0.09$) were similar in the two groups. Feed efficiency (1.45 vs. 1.32%, $P < 0.01$), and milk N efficiency (29.68 vs. 26.67%, $P < 0.01$) were higher for control group compared with CS group. In conclusion, replacing alfalfa hay and corn silage with corn straw decreased milk production, and affected milk composition.

Key Words: milk composition, forage, dairy cow

1650 (M364) The use of favored or unfavored ingredients in starter feeds for preweaned calves. M. Terré[*1], and A. Bach[2], *[1]IRTA, Caldes de Montbui, Spain, [2]Dep. of Ruminant Production, IRTA, Caldes de Montbui, Spain.*

When calves are allowed to choose among different ingredients, soybean meal and wheat are the most consumed ingredients commonly used in starter concentrates, whereas canola and oats are among the least consumed. The objective of this study was to evaluate three different starter feeds containing ingredients of different acceptance by calves. Sixty-three (n = 21) Holstein male calves (41 ± 1.3 kg BW, 9 ± 0.9 d of age) were grouped in three treatments: a starter feed (18.6% CP, 21.4% NDF) based on soybean meal (17.5%), wheat (22%) and corn (24%), a starter feed (18.1% CP, 21.5% NDF) based on canola (15%), wheat (22%) and corn (18%), and a starter feed (20.3% CP, 18.5% NDF) based on soybean meal (18.5%), oats (24%) and corn (26.5%). All starter feeds were in a pellet form, and straw was also offered ad libitum. The milk replacer feeding program was the same for all three treatments: 4 L/d at 12.5% DM concentration from 1 to 7 d of study, 6 L/d at 12.5% DM from 8 to 35 d of study, and 3 L/d at 12.5% DM from 36 to 42 d (weaning). Animals were weighed weekly until the end of the study at 49 d, and milk replacer and starter feed intake measured daily. At 30 and 50 d of study, liquid rumen samples were obtained to determine rumen pH. Data were analyzed by PROC MIXED of SAS with repeated measures, being concentrate ingredients composition and week of the study, and their interaction the main effects, and initial BW as a covariate. Animals in all three treatments had similar performance and intake parameters (0.64 ± 0.045 kg DM/d of starter intake, 0.62 ± 0.027 kg/d of ADG). There were no differences in rumen pH (5.65 ± 0.084 pH) among the three treatments. In conclusion, the inclusion of a non-favored ingredient such as canola or oats in a pelleted starter feed did not affect performance parameters of preweaned calves.

Key Words: calf, ingredient composition, performance