

Forages and Pastures III

W92 Chemical composition of oats straw treated with oxidizing and alkali-based agents. F. E. Miccoli^{1,2}, H. M. Arelovich^{2,3}, R. D. Bravo^{2,3}, and M. F. Martínez^{2,4}, ¹Facultad de Ciencias Agrarias, Universidad Nacional de Lomas de Zamora, Buenos Aires, Argentina, ²Departamento de Agronomía, Universidad Nacional del Sur, Bahía Blanca, Argentina, ³Comisión de Investigaciones Científicas (CIC), Buenos Aires, Argentina, ⁴CERZOS-CONICET, Bahía Blanca, Argentina.

Specific chemical treatments improve feeding value of straws by dissolving chemical bonds of cell wall components without affecting lignin content, which may be decreased by oxidizing agents. The objective was to evaluate the effect of oxidizing and alkali-based agents added in aqueous solution to improve feeding value of chopped oats straw (*Avena sativa*, OS). Treatments were CON (control); U = urea (4 g/100 g DM); SH = NaClO (1 g active Cl/100 g DM); SC = NaCl (4 g/100 g DM); and the combinations U-SH; U-SC; SH-SC and U-SH-SC. A volume of 30 mL of each solution was sprayed and homogenized with 100 g DM of OS, compacted and stored for 10, 20 or 30 d in 10 × 15 cm PVC cylinders. The storage temperature was 24.1 ± 1.8°C. After storage samples were dried (65°C), ground (2mm) and analyzed for IVDMD, CP, NDF, ADF and ADL. Data were analyzed as a factorial arrangement of treatments with 4 replicates and means were compared using Tukey's test. Interaction ($P < 0.01$) between chemical treatments and storage length was only found for CP and ADL. Thus IVDMD, NDF and ADF across storage lengths are reported on Table 1 since chemical treatment is the main factor. The CP concentration did not change within treatments without urea in any storage length, averaging 2.36%. However, U, U-SH, U-SC and U-SH-SC averaged 10.30% CP being 4.4 times greater than treatments without urea. The combination of urea with oxidizing and alkali-based agents (U-SH, U-SC and U-SH-SC) promoted even larger N retention in OS than U alone ($P < 0.05$). The main reduction of ADL was noted at 30 d storage length ($P < 0.05$) with SH-SC (4.43%) vs. CON (6.28%). Combined oxidizing and alkali-based agents substantially improved feeding value of OS.

Table 1. Effect of oxidizing and alkali-based agents on oats straw quality

Treatment	IVDMD	NDF	ADF
CON	47.38 ^a	79.57 ^e	44.37 ^c
U	52.10 ^{bc}	76.72 ^{cd}	43.27 ^{bc}
SC	49.77 ^{ab}	78.85 ^e	43.72 ^c
SH	49.91 ^{ab}	78.19 ^{de}	43.71 ^c
U-SC	54.00 ^c	74.49 ^b	41.34 ^{ab}
U-SH	53.23 ^{bc}	75.22 ^{bc}	41.59 ^{ab}
SC-SH	53.65 ^{bc}	73.67 ^{ab}	42.57 ^{bc}
U-SC-SH	54.11 ^c	72.26 ^a	40.32 ^a
SEM	0.91	0.38	0.44

^{a-c}Means in the same column with different superscripts differ ($P < 0.05$).

Key Words: oats straw, forage quality, chemical treatment

W93 In vitro true organic matter digestibility, partitioning factor, and ruminal microbial protein synthesis of crown rust resistant and susceptible oat cultivars in Northern Mexico. H. Bernal Barragán^{*1,4}, M. A. Cerrillo Soto^{2,4}, A. S. Juárez Reyes^{2,4}, M. Guerrero Cervantes^{2,4}, N. C. Vásquez Aguilar¹, F. G. Ríos Rincón^{3,4}, E. Gutiérrez Ornelas^{1,4}, and J. E. Treviño Ramírez¹,

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This study was conducted to evaluate the nutritional value of 3 crown rust (*Puccinia coronata*) resistant oat cultivars (CRR = L112, L124 and L164), released from the Agronomy Dept. of the University of Nuevo Leon, Mexico, and of 2 commercial crown rust susceptible cultivars (CRS = Guelatao and Chihuahua) using in vitro procedures. Whole plant samples were harvested April 2008 at 3 growth days (d), and grouped in a 2 × 3 factorial arrangement of treatments, with 2 groups of cultivars (CRR and CRS), and 3 growth stages (101, 110, and 117 d), in a complete randomized design, without accounting for single varieties. No crown rust disease infested any of the experimental plots. Incubations of 500 mg samples were set in 40 mL of a 1:2 mixture of rumen fluid from 3 fistulated sheep fed 75% alfalfa hay and 25% concentrate, and buffer solution, in calibrated 100 mL glass syringes at 39°C, to determine mL gas production at 24h (GP_{24h}). True in vitro dry matter degradability (TIVDMDegr) was determined after refluxing the 24h-incubation residuals in NDF solution. Partitioning factor (PF) was calculated as mg true degraded DM/GP_{24h}. Microbial protein (MP) synthesis was estimated measuring UV-spectrophotometrically the purine content (μmol) of additional freeze-dried 24h-incubation residuals. True in vitro OM digestibility (TIVOMDig) was determined after incubating 250 mg samples in a Daisy (ANKOM) fiber digester. There was an interaction ($P < 0.01$) for GP_{24h}, since beginning with similar values at 101 d (avg. 86.5 ± 1.8), GP_{24h} for CRS increased until 117 d (89.9 ± 2.2 SE), whereas CRR decreased to 74.3 ± 1.8 mL. TIVDMDegr increased ($P < 0.05$) at 117 d (58.1 ± 0.9%) compared with 101 and 110 d (avg. 42.8 ± 0.9%). The PF of CRR at 117 d was higher than CRS (3.80 ± 0.08 vs 3.35 ± 0.10, $P < 0.05$), however (interaction $P < 0.05$) PF was similar earlier (avg. 2.50 ± 0.08). TIVOMDig at 101 d was higher than 117 d (72.1 ± 0.8 vs 66.8 ± 0.8%, $P < 0.01$); no difference was found between CRR and CRS. There was increased MP of CRS compared with CRR at 110 (9.0 ± 0.6 vs 7.5 ± 0.5) and 117 d (8.1 ± 0.6 vs 5.8 ± 0.5 μmol) but (Interaction $P < 0.05$) MP was similar (avg. 6.0 ± 0.6) at 101 d. In conclusion, TIVOMDig was higher at 101 d than later. GP_{24h} and MP of CRS at 110 and 117 d were higher than CRR.

Key Words: oat forage, crown rust, ruminal digestibility

W94 On farm corn silage evaluation method and its validation in a field study. B. Andrieu,* A. Perilhou, and J. Sindou, *Lallemand SAS, Blagnac, France.*

Many silages present some preservation issues, but measuring silo parameters on farm is not always an easy practice. Therefore, a toolbox and its accompanying software (Corn Silage Investigation (CSI) software) were developed to allow a diagnosis of corn silage quality on farm. To validate the concept a large-scale field study was performed. 51 farms located in several areas of France were diagnosed using the toolbox. Temperature, pH and density were recorded as described by the method and the corresponding values were entered in the CSI-software. In addition, parameters describing the farm (breeding performance, field management) and the harvest (type of harvester, speed, yield and application of silage inoculants) were noted. Samples at specific sampling

points were taken for chemical analysis (VFA, ammonia, feeding value, monopropylene glycol). Data from the field survey were subjected to 1-way ANOVA. For each farm the CSI-software provided a report in which their values were graphically depicted versus benchmarks, which facilitates interpretation of the data. Results from the field survey showed that 30% of the silos had a density lower than the target value (240 kg DM/m³). The density was correlated with parameters at harvest (weight of the tractor, harvest speed), specifications of the corn (DM and chop length) and bunker specifications. It was also recorded that 36% of the investigated silage was heating up (>3°C above ambient temperature). Treating the silage with an inoculant showed to be beneficial. Not only was the percentage of silages that showed heating lower (60% for non treated (NTS) vs 16% for treated silage (TS)), the average increase of temperature was also significantly lower (+8°C for NTS versus +1°C for TS, $P \leq 0.05$) as well as the maximum temperature reached (51°C for NTS versus 28°C for silage treated with *L. buchneri* 40788 versus 47°C for silage treated with *L. buchneri* 202118, $P \leq 0.01$). The toolbox and the CSI-software have proven a practical tool to evaluate the quality of silage. The field study confirms that good management of several parameters (silo design, harvest parameters, etc.) are essential for good silage quality. The addition of a silage additive such as *Lactobacillus buchneri* can help optimizing these good management practices.

Key Words: corn silage quality, field survey, *L. buchneri*

W95 Transgenic corn hybrids reduce fungi in silage. G. B. Neto^{*1}, T. M. dos Santos Cividanes¹, R. B. F. Branco¹, A. L. Fachin², M. C. Beraldo², and T. A. Bitencourt², ¹Agência Paulista de Tecnologia dos Agronegócios da Secretaria da Agricultura e Abastecimento do Estado de São Paulo, Ribeirão Preto, São Paulo, Brazil, ²Universidade de Ribeirão Preto, Ribeirão Preto, São Paulo, Brazil.

The presence of fungi was evaluated in 4 hybrid maize silages, DKB 390 and AG 8088, with (GMO) or without (near-isogenic non *Bt*) the *cry1Ab Bacillus thuringiensis* gene. The GMO was not treated with insecticide, and the conventional hybrids received one deltamethrin (2.8%) application 42 d after planting. The harvest was done 95 d after planting. The experimental design was the randomized block with 5 replications in a 2 × 2 factorial arrangement. The GMO had a reduce incidence of fungi in the silage ($P < 0.001$). The total-count averages in the GMO and conventional hybrid silages for filamentous fungi were of 12×10^3 and 3.4×10^5 cfu/g and 13×10^3 and 1.1×10^6 cfu/g for yeast, respectively. However, grain, leaf and stalk ionizant radiation samples were tested for their capacity to inhibit the formation of fungi, such as *Aspergillus flavus*, *Penicillium sp.*, *Fusarium oxysporum*, *Fusarium verticilloides*, and no significant differences were found ($P > 0.05$). Thus, the smaller fungi population in the GMO silage was attributed to a higher defense capacity of the plant against the armyworm *Spodoptera frugiperda*. The average damage caused by the *S. frugiperda*, determined in 25 plants per treatment through a visual scale from 0 (no damage) to 5 (dead plants), was of 1.04, 1.60, 1.52, 1.52, 1.68 in GMO and 2.08, 2.28, 2.68, 2.84 and 2.80 in conventional hybrids 15, 22, 29, 36 and 46 d after planting, respectively. Although the GMO was highly effective against *S. frugiperda* ($P < 0.001$), it was not as effective against *Helicoverpa zea* 71 and 78 d after planting ($P > 0.05$). The average damage caused by *H. zea*, determined through a visual scale from 0 (no damage) to 4 (severe damage), was of 0.72 and 1.04 in GMO and 0.84 and 0.96 in conventional hybrids, respectively. Insect damage in plants plays an important role in mold infestation because these events cause the disruption of the protective cell wall. This creates entry points for infective molds. In addition, it causes release of nutrients from the plant endosperm that can be used by molds for growth. The results indicate

that the GMO studied likely indirectly reduces fungi populations in silage through reduced impact of armyworm infestations.

Key Words: armyworm, mold

W96 Effects of DM concentrations and inoculants on Jiggs and Tifton 85 bermudagrass silage. J. M. B. Vendramini^{*1}, A. T. Adesogan², L. E. Sollenberger³, A. D. Aguiar¹, A. Valente¹, and P. Salvo¹, ¹UF/IFAS Range Cattle Research and Education Center, Ona, FL, ²Department of Animal Sciences, Gainesville, FL, ³Department of Agronomy, Gainesville, FL.

Bermudagrass is the main warm-season grass species preserved as silage or haylage by dairy producers in Florida; however, the nutritive value and silage fermentation parameters are often less than desirable. The objective of this study was to investigate the effects of DM concentrations on nutritive value and fermentation parameters of Jiggs bermudagrass (*Cynodon dactylon* L.) and Tifton 85 bermudagrass (*Cynodon* sp.) silages treated with sugarcane (*Saccharum officinarum*) molasses [1 kg molasses (DM)/50 kg forage (As fed)], Ecosyl inoculant [EcoSyl, MTD/1; 100 mg/50 Mg forage (As fed)], B 500 inoculant [*Lactobacillus buchneri*, 8 mg/kg forage (As fed)], or control. The experiment was conducted in Ona, FL. Tifton 85 and Jiggs plots were distributed in a randomized complete block design with 3 replicates. The data were analyzed using PROC MIXED with bermudagrass cultivars (main plot), DM concentrations (sub-plot), and inoculants (sub-sub-plot) as fixed effects, and block and its interactions as random effects. Forage was harvested with 4 wk regrowth and readily ensiled (22% DM) or wilted on the field for 4 h (53% DM). Forage was packed into a mini-silo at a density of approximately 400 kg fresh forage/m³ and ensiled for 90 d. There were no effects ($P < 0.05$) of species, DM concentrations, or inoculants on CP concentrations (12.2%). Forage with greater DM concentration had greater in vitro true digestibility (IVTD; $P < 0.01$, SE = 1, 56 vs. 53% for 53 and 22% DM, respectively) and the molasses treatment resulted in forage with greater IVTD than the other inoculant treatments ($P < 0.01$, SE = 1, 58 vs. 53%). However, silage with greater DM concentration had greater pH ($P = 0.02$, SE = 0.6, 4.5 vs. 4.8 for 22 and 53% DM, respectively) and decreased lactic acid concentrations ($P < 0.01$, SE = 0.1, 3.8 vs. 2.9% for 22 and 53% DM, respectively). Silage treated with molasses had decreased pH ($P < 0.01$, SE = 0.04, 4.3 vs. 4.8), increased acid lactic concentrations ($P < 0.01$, SE = 0.05, 5.4 vs. 2.4), and decreased aerobic stability when compared with forage treated with Ecosyl, B 500, and control ($P < 0.01$, SE = 11, 205 vs. 288 h). Using molasses as an additive may improve the nutritive value and fermentation characteristics of bermudagrass silage.

Key Words: bermudagrass, silage, inoculant

W97 Effects of Lactobacillus inoculants and forage dry matter on the fermentation and aerobic stability of ensiled mixed-crop tall fescue and meadow fescue. X. S. Guo¹, D. J. Undersander², and D. K. Combs^{*2}, ¹State Key Laboratory of Pastoral Ecosystem, Lanzhou University, Lanzhou, China, ²University of Wisconsin, Madison.

This study evaluated the effects of *Lactobacillus plantarum* with or without *Lactobacillus buchneri* on the fermentation and aerobic stability of a mixture of tall fescue and meadow fescue ensiled at different dry matter. The first cut was harvested at boot stage and second-cut grasses were harvested when 30 to 35 cm tall. Four DM content treatments of the first-cut were 17.9%, 24.9%, 34.6%, and 48.7%; and of second-cut were 29.1%, 36.3%, 44.1%, and 49.2%. Chopped grasses at each DM content were treated with 1) deionized water (control); 2) *L. plantarum* MTD1

(LP); 3) a combination of *L. plantarum* MTD-1 with *L. buchneri* 40788 (LP+LB). The application rate of each inoculant to the fresh forage was 1×10^6 cfu/g. Grasses were ensiled in vacuum sealed polyethylene bags for 60 d with 4 replicates for each treatment, and each bag contained 150 g of DM. Aerobic stability was defined as the time after bag opening for the silage temperature to increase by 2°C above ambient temperature. Data were analyzed by using the GLM procedure of SAS according to a randomized complete block design. Silages inoculated with LP+LB or LP had greater pH compared with untreated silages (5.07, 5.04, 4.86, respectively, $P < 0.05$). Lactate was greater in LP silage (5.25% DM) than control (3.75%DM) or LP+LB (2.84%DM) silages ($P < 0.05$). As silage DM increased, lactate in untreated and LP treated silages decreased, but increased in LP+LB treated silage ($P < 0.001$). Acetate concentration decreased with increased DM in all silages. LP+LB treated silage had the longest and control silage the shortest aerobic stability for both harvests. The greatest values in aerobic stability were observed in silages with highest DM content ($P < 0.05$). In this study, aerobic stability of grass mixes ensiled between 18% and 44% DM increased as DM% increased. LP and LP+LB inoculants improved aerobic stability of silages harvested between 18% and 44% DM.

Key Words: fescue, silage, inoculant

W98 Effect of corn silage sample handling on nutritional parameters measured by wet chemistry. L. C. Solórzano*¹, D. Sawyer², and A. A. Rodríguez³, ¹*Chr. Hansen Inc., Milwaukee, WI*, ²*Rock River Laboratory Inc., Watertown, WI*, ³*University of Puerto Rico, Mayagüez, PR*.

Prior to ration balancing, nutritionists submit samples to a laboratory for analysis. Many times, samples must be shipped to the laboratory as services may not be readily available nearby. Shipping methods vary, thus the time that lapses between sample collection and sample analysis may range from a few hours to a few days. A study was undertaken to determine the effect of silage sample handling on nutritional parameters measured by wet chemistry at a commercial laboratory. Eleven silage storage bags were sampled with a silage probe. Each individual silage bag sample was thoroughly mixed and divided into 5 sub-samples that were treated as follows: 1. Silage sub-sample placed in air tight bag and iced immediately, taken to the laboratory within 3.5 h (ICE); 2. Silage sub-sample placed in airtight bag, taken to the laboratory within 3.5 h (NO-ICE); 3. Silage sub-sample placed in airtight bag, taken to post office for overnight delivery (24H); 4. Silage sub-sample placed in air tight bag, iced, taken to freezer overnight and taken to post office for overnight delivery (48HFZN); 5. Silage sub-sample placed in airtight bag, kept overnight at room temperature in garage and taken to post office for overnight delivery (48H). All 55 silage sub-samples were analyzed for pH, CP, ADF and heat damaged CP at a properly accredited commercial laboratory (Rock River Laboratory, Inc., Watertown, WI). Statistical analysis was performed using SAS with a model containing terms for silage bag number and treatment. Separation of treatment means was conducted using the Tukey-Kramer test. Silage pH did not differ among treatments and averaged 3.84. The CP content (%) for 48HFZN (7.39) was increased ($P < 0.03$) relative to ICE (6.97), NO-ICE (6.91), 24H (6.79) and 48H (7.1). The available CP (DM %) for 48HFZN (7.16) was increased ($P < 0.03$) relative to ICE (6.71), NO-ICE (6.69), 24H (6.57) and 48H (6.74). The ADF insoluble CP (% CP) was increased in 48H (5.09) relative to ICE (3.8), NO-ICE (3.11), 24H (3.32) and 48HFZN (3.12). There were no treatment effects ($P > 0.10$) for ADF or energy parameters. Samples arriving to the laboratory after 24 h post-sampling are subject to increases in CP content regardless of the handling method. Samples arriving to the laboratory after 24 h

post sampling are subject to increases in heat-damaged protein when not kept cold or frozen. Data suggest that samples should arrive to the laboratory within 24 h post sampling in tightly sealed bags.

Key Words: corn silage, nutrients, sample handling

W99 The effect of ensiling duration on fatty acid profile and concentration of corn silage. M. C. Der Bedrosian*¹, L. Kung Jr.¹, K. E. Nestor Jr.², C. L. Preseault³, and A. L. Lock³, ¹*University of Delaware, Newark*, ²*Mycogen Seeds, Indianapolis, IN*, ³*Michigan State University, East Lansing*.

The profile and concentration of fatty acids (FA) in feed has been shown to affect rumen function, and the yield of milk and milk components. The objective of this study was to evaluate the effect of ensiling duration on the profile and concentration of FA of corn silage. Treatments were a brown midrib (BMR) and a non-BMR silage hybrid (nBMR), both harvested at a normal DM (32%) and a high DM (41%). Forages were sampled, vacuumed and heat-sealed in storage bags ($n = 5$) and ensiled for 45, 90, 180, 270, or 360 d, before analyses. Fatty acids were analyzed by gas-liquid chromatography. Data were analyzed as a $5 \times 2 \times 2$ factorial arrangement of treatments, with main effects of hybrid, DM at harvest, ensiling duration, and interactions of each. The total concentration of FA (DM basis) was 1.9%, 2.0%, 1.9%, and 2.20% after 0, 45, 90 and 180 d, respectively. After 270 d and 360 d, the concentration of FA was increased ($P < 0.01$) over d 0 and 90 d to 2.3%. Harvesting nBMR at a normal DM ($1.3 \pm 0.06\%$) resulted in lower ($P < 0.01$) FA concentration, than harvesting at a high DM ($2.4 \pm 0.06\%$). This difference was absent in BMR silages, averaging 2.5% and 2.3% for normal and high DM silages, respectively ($P > 0.05$). When the FA profile was examined, the concentration of total PUFA was lower in high DM BMR (50 g/100 g FA) than low DM BMR (53 g/100 g FA) and normal DM nBMR (53 g/100 g FA) ($P < 0.01$). Levels of total PUFA were highest in high DM nBMR (55 g/100 g FA). Total PUFA concentration was, on average, 52.7 g/100 g FA after 0 d, decreased ($P < 0.01$) to 49.9 g/100 g FA after 45d, then increased ($P < 0.01$) to 51.0 g/100 g FA, 54.8 g/100 g FA, 54.8 g/100 g FA and 55.3 g/100 g FA after 90, 180, 270 d, and 360 d, respectively. The mean concentration of linoleic acid and oleic acid was 48 and 25 g/100 g FA, respectively, averaged over all time points and silages, and remained steady over time. Linoleic acid was highest in high DM nBMR (51.2 g/100 g FA) and was lowest in normal DM nBMR (44 g/100 g FA, $P < 0.01$). Linoleic acid concentration increased with time ($P < 0.01$) in all other silages, and this increase was most dramatic in normal DM nBMR. Total MUFA (g/100 g FA) were steady over time in nBMR silages, ranging from 24.4 g/100 g FA, before ensiling, to 23.2 g/100 g FA, after 360 d of storage. In BMR silages, total MUFA levels peaked after 45 d of ensiling at 29.0 g/100 g FA, then decreased steadily ($P < 0.01$) to 26.8 g/100 g FA. Levels of oleic acid remained steady over time in nBMR silages, but fluctuated over time ($P < 0.01$), peaking after 45 d of ensiling at 27.9 g/100 g FA, and decreasing to 26.1 g/100 g FA after 270 d. These results indicate that on a DM basis FA concentration in corn silage changes during ensiling. It remains to be determined, however whether such changes are an increase in actual FA yields or due to a reduction of non-FA material within the forage. Future work should examine whether these FA are present as free or esterified FA and if this changes during ensiling.

Key Words: corn silage, BMR, fatty acids

W100 Relationship between organoleptic characteristics, pH, and aerobic deterioration of alfalfa and orchard grass silages. R. González-Ortiz¹, L. Miranda-Romero¹, J. Burgueño-Ferreira², and R. Améndola-Massiotti^{*1}, ¹*Posgrado en Producción Animal Universidad Autónoma Chapingo, Chapingo, Estado de México, México*, ²*CIMMYT, Texcoco, Estado de México, México*.

The perception of organoleptic properties (OP; odor, color, structure and moisture) of silages by trained observers enables an easy subjective evaluation of quality. On the other hand, chemical properties (CP) as pH and aerobic deterioration (measured as CO₂ production TPCO₂, mmol CO₂ g⁻¹ dry matter d⁻¹, measured during 5 d of exposure to air) are quantitative objective assessments of silage quality, but they are not easily available to small farmers. The aim was to estimate the relationship between OP and CP of 46 alfalfa (*Medicago sativa* L.) and orchard grass (*Dactylis glomerata* L.) silages. The experiment was carried out between June and August 2011, at Chapingo University, México. The silages resulted of the factorial combination of cutting at 2 different hours (8:00 and 14:00), 3 wilting times (0, 1 and 2 h) and 2 levels of bacterial inoculants (0 and 5g t⁻¹) with 4 replicates. Forage was ensiled in 200 L plastic containers, and opening of silos took place 60 d after ensiling. Perception of OP was carried out by 5 previously trained independent observers. The different OP were classified in 4 classes ranging between 1 (bad) and 4 (excellent). Silage samples were taken for measurement of pH and TPCO₂. Correlations analysis and principal components analysis were carried out. Correlation coefficients (r) among OP ranged between 0.57 and 0.87, while r between CP was 0.39; CP were negatively correlated with OP, r ranged between -0.34 (pH-odor) and -0.67 (TPCO₂ -moisture). Even though r were low, they were all significant ($P \leq 0.02$). Principal components analysis enabled the classification of silages according to their quality. The first 2 components explained 80% of the variation; the first component (70%) implied the negative relationship between CP and OP; according to the second component CP were positively related to odor and color and negatively related to moisture. Due to the close relationship between OP and CP it is concluded that small farmers might reliably use perception of OP for the evaluation of silage quality.

Key Words: *Medicago sativa*, *Dactylis glomerata*, principal components analysis

W101 Effect of rate of application of various commercial exogenous fibrolytic enzymes on preingestive fiber hydrolysis and release of sugars and phenolics from bermudagrass haylage. J. J. Romero^{*1}, K. G. Arriola¹, M. A. Zarate¹, C. R. Staples¹, C. F. Gonzalez², W. Vermerris³, and A. T. Adesogan¹, ¹*Department of Animal Sciences, IFAS, University of Florida, Gainesville*, ²*Department of Microbiology and Cell Science, IFAS, University of Florida, Gainesville*, ³*Department of Agronomy, IFAS, University of Florida, Gainesville*.

The objective was to examine effects of the dose rate of 5 commercial exogenous fibrolytic enzymes (EFE; E1, E2, E3, E4, and E5 containing 1506, 286, 3624, 1693 and 70 $\mu\text{mol}/\text{min}/\text{g}$ endoglucanase activity, respectively) on fiber hydrolysis of a 4-wk regrowth of Tifton 85 bermudagrass haylage. Dose rates were 0x (Control), 0.5x, 1x, 2x and 3x; where 1x was the recommended rate of 10, 15, 2.25, 2.25, and 15 g/kg ground (1 mm) substrate, respectively. Enzymes were diluted in citrate-phosphate buffer (pH 6) containing sodium azide (0.02% w/v) and were applied in quadruplicate in 2 runs. Suspensions were incubated at 25°C for 24 h before addition of 15 mL of water followed by shaking for 1

h and filtration through a Whatman 451 paper. Data for each enzyme were analyzed separately as a completely randomized block design. The model included effects of dose, run, and the interaction. Linear (L), quadratic(Q) and cubic (C) polynomial contrasts and the PDIFF statement of SAS were used to evaluate means. Increasing the dose rate increased ($P < 0.05$) DM loss (%) of substrates treated with E3 and E4 (C), E1 (Q), and E2 and E5 (L); decreased ($P < 0.04$) the NDF (%) of all enzyme-treated substrates (C); decreased ($P < 0.01$) ADF (%) of E2, E3, E4 and E5 (C), and E1 (Q); decreased ($P < 0.02$) hemicellulose (%) of E2, E3 and E5 (C), and E1 and E4 (Q); decreased ($P < 0.03$) cellulose (%) of E2, E3, E4, and E5 (C), and E1 (Q); increased ($P < 0.01$) release of water soluble carbohydrates (WSC, %) from E2, E3, E4, and E5 (C), and E1 (Q) and increased ($P < 0.01$) release of ferulic acid (FER, $\mu\text{g}/\text{g}$) from E1, E2, E3 and E5(C), and E4 (L). Optimal doses for reducing the % NDF of E1, E2, E3, E4 and E5 were 2x (-6.7), 0.5x (-1.9), 3x (-8.3), 2x (-3.8) and 3x (-4.0), respectively. Optimal doses for increasing release (%) of WSC and ($\mu\text{g}/\text{g}$) FER were 3x (+5.9), 3x (+0.7), 3x (+5.1), 3x (+2.4) and 3x (+1.3) and 3x (+37), 0.5x (+6), 3x (+54), 2x (+11) and 2x (+30), respectively. Increasing dose rates beyond manufacturer recommendations increased fiber hydrolysis by enzymes to different extents.

Key Words: forage, enzyme, dose

W102 The effects of bacterial inoculants and enzymes on the fermentation, aerobic stability and in vitro organic matter digestibility characteristics of sunflower silages. M. L. Ozduven^{*1}, F. Koc¹, and V. Akay², ¹*Namik Kemal University, Tekirdag, Turkey*, ²*Global Nutritech Biotechnology LLC, Richmond, VA*.

This study was carried out to determine the effects of lactic acid bacteria, enzymes, and lactic acid bacteria+enzyme mixture on the fermentation, cell wall contents, aerobic stability and in vitro organic matter digestibility characteristics of sunflower silages. Sunflower was harvested at the milk stage of maturity. Treatments were: 1) control; 2) lactic acid bacteria (I; Global Nutritech Biotechnology LLC, Richmond, VA); 3) enzyme (E; Global Nutritech Biotechnology LLC, Richmond, VA); and 4) lactic acid bacteria+enzyme mixture inoculants (I+E; SILAID; Global Nutritech Biotechnology LLC, Richmond, VA). Inoculants were applied to silages at the rate of 6.00 log cfu/g. Treated chopped sunflower was ensiled in 1.0-l special anaerobic jars equipped with a lid enabling gas release only. The jars were stored at 25 \pm 2°C under laboratory conditions. Three jars from each group were sampled for chemical and microbiological analysis at 2, 4, 8, 15 and 60 d after ensiling. At the end of the ensiling period, all silages were subjected to an aerobic stability test for 5 d by measuring pH, production of CO₂, and growth of yeast and mold. In addition, in vitro organic matter digestibilities of these silages were determined. Both treatments (I and I+E) increased characteristics of fermentation but impaired aerobic stability of sunflower silages compared with control ($P \leq 0.05$). Bacteria+enzyme treatment decreased both neutral detergent fiber and acid detergent fiber contents of silage compared with control ($P \leq 0.05$). In vitro organic matter digestibility was numerically increased for treated silages compared with control silages. In conclusion, I and I+E inoculants can be used for sunflower silages.

Key Words: sunflower, silage, inoculant

W103 The inoculation rate of a mixture of homo-fermentative and hetero-fermentative bacteria strains affects the aerobic stability of tropical corn (TC) silage. A. A. Rodríguez*¹, L. C. Solórzano², and V. Rivera¹, ¹University of Puerto Rico, Mayagüez, PR, ²Chr. Hansen Inc., Milwaukee, WI.

The objective was to evaluate the effects of inoculation rate of a microbial additive containing homo-fermentative and hetero-fermentative lactic acid-producing bacteria strains (LAPBI) on the ensiling characteristics and aerobic stability of TC fermented during 45 and 90 d (FD) at 27°C. Chopped TC (38.21% DM) was ensiled in 1.2 kg capacity micro-silos and assigned to 1 of 3 treatments (TRT); no additive, LAPBI applied at 10⁵ or at 10⁶cfu/g fresh forage. Three samples of fresh forage and silage from each TRT and FD were analyzed to determine pH and fermentation products. Statistical analysis was performed according to a Completely Randomized Design with a 3 TRT by 3 FD factorial arrangement. For aerobic stability, triplicate samples from each TRT and FD were placed in styrofoam containers lined with plastic. Temperature was measured at 6 h intervals from 0 to 108 h and at 124, 130, 134, 140, 148, 158, and 176 h. Data was analyzed using a split plot design with a 3 TRT by 2 FD by 26 h factorial arrangement using silo as the repetitive measurement. No significant ($P > 0.05$) responses on pH and fermentation characteristics were observed. After 45 d of ensiling and during the aerobic exposure (AE) period temperature was lower ($P < 0.05$) in TC treated with 10⁶ cfu/g LAPBI than control or TC inoculated with LAPBI applied at 10⁵cfu/g. After 90 d of ensiling temperature was lower ($P < 0.05$) in treated silages vs. control. The temperature of inoculated silages fermented during 45 and 90 d was lower ($P < 0.05$) vs. control from 54 to 84 h and from 90 to 108 h of AE, respectively. Compared with ambient temperature, after 45 d of ensiling temperature started to rise at 36 h of AE for control and silage treated with 10⁵ cfu/g, whereas in silage treated with 10⁶ cfu/g it occurred after 54 h. After 90 d of ensiling, inoculation with 10⁶ or 10⁵ cfu/g delayed the start of temperature rise for 78 or 72 h, whereas for untreated TC the delay was 66 h. In summary, inoculation of TC did not enhance the fermentation characteristics, but improved aerobic stability. A greater response in aerobic stability was observed with the higher inoculation rate.

Key Words: tropical corn silage, microbial inoculants, inoculation rate

W104 Infrared thermography to assess the relationship between corn silage quality and face temperature. L. O. Abdelhadi*¹, P. A. Saravia², W. R. Barneix², C. A. Malaspina², C. de Elia³, and J. M. Tricarico⁴, ¹Est. El Encuentro, Research and Extension in Ruminant Nutrition, Brandsen, Buenos Aires, Argentina, ²Cámara Argentina de Contratistas Forrajeros (CACF), Argentina, ³Alltech Biotechnology, Argentina, ⁴Innovation Center for U.S. Dairy, Rosemont, IL.

Feedout exposes silage to air consequently reducing silage quality and resulting in environmental implications. The aim of the study was to evaluate the utilization of infrared thermography (IRT) to relate face temperature with quality losses and ethanol emissions, and develop a tool that allows us to act rapidly to improve management and hence reducing the negative effects of air exposure. A randomized complete block design was used with bunker silos as blocks and face temperatures as treatments. Corn silage storage in bunker silos were sampled in 18 commercial well managed dairy and beef farms. A hand portable infrared camera (Ti45, Fluke thermal imagers) was used to measure IRT in each silo at a fixed distance of 4 m. From this measurement, the locations of maximum (Hot) and minimum (Cold) temperatures were established in exposed silo face. At each point samples were taken using a forage sampler (between 0 and 50 and 50–100cm depth), frozen and analyzed

for DM, OM, CP, pH and in vitro DM digestibility (DMD) at 6, 12, 24 and 48h of incubation (DAISY). As expected, temperature from hot to cold locations differed by $13.9 \pm 3.5^\circ\text{C}$ ($P < 0.01$). Although no differences in quality parameters and pH were detected between 0 and 50 cm depth, a reduction in OM was detected from 50 to 100 cm in hot areas ($P < 0.09$). DMD at 48h was lower ($P < 0.01$) both between 0 and 50 and 50–100 cm depth in hot areas, when compared with cold ones. Besides at 6h, DMD was higher in cold areas. Although strong correlations were no detected for temperature and quality parameters in the type of silos involved in this trial, we conclude that hot areas in silo faces represents reductions in DMD which could be detected by IRT technology.

Table 1.

Variable	Sampling site			Sampling site		
	0-50cm (n=18)			50-100 cm (n=18)		
	Hot	Cold	SE	Hot	Cold	SE
T°C	27.23 ^a	13.34 ^b	0.579	27.23 ^a	13.34 ^b	0.579
DM %	32.41	31.66	0.344	31.82	31.69	0.313
pH	4.06	3.99	0.053	3.98	3.98	0.009
% on DM Basis						
OM	92.92	93.21	0.172	93.15 ^b	93.61 ^a	0.145
CP	6.62	6.31	0.153	6.48	6.31	0.162
DMDh6	45.10	46.17	0.899	45.86 ^b	47.65 ^a	0.699
DMDh12	50.91	51.72	0.808	51.79	51.94	1.054
DMDh24	62.38	63.55	0.944	62.42	63.54	0.591
DMDh48	68.23 ^b	72.52 ^a	0.699	69.59 ^b	73.10 ^a	0.488

^{ab}Means within a row with unlike letters differ ($P < 0.09$). T = face temperature.

Key Words: corn silage, infrared thermography, quality

W105 Fermentative losses and yeasts population in sugarcane ensiled with different particle sizes. A. F. Campos*¹, G. R. Siqueira^{1,2}, V. D. Monção³, and R. A. Reis¹, ¹São Paulo State University, Jaboticabal, São Paulo, Brazil, ²Agência Paulista de Tecnologia dos Agronegócios, Colina, São Paulo, Brazil, ³Centro Universitário de Barretos, Barretos, São Paulo, Brazil.

The objective of this study was to evaluate the gas losses, effluent production, dry matter recovery, pH and the dynamics of yeasts population in silages of sugarcane with different particle size (0.5; 1.0; 1.5 and 2.0 cm). The silages were evaluated during the storage period of 0, 3, 7, 14, 28 and 56 d of fermentation. Results were analyzed in a completely randomized design, with 3 replications, with time repeated measures, using plastic bucket like experimental silos. Statistical analyzes were developed using MIXED procedure of SAS 9.0. It was observed significant differences ($P < 0.01$) in gas production. Silage with particle size of 1.0 cm showed greatest losses ($85.4 \times 66.4, 72.3$ and 61.2 g/kg on the silages of 0.5; 1.5 and 2.0 cm, respectively). The gas losses increased until 28 d of fermentation. There were no significant differences ($P > 0.05$) in the dry matter recovery among the treatments, but there was a reduction ($P < 0.01$) along the days of fermentation. Yeast population was higher in the silages with 1.0 and 1.5 cm of particle size, compared with the treatments with 0.5 and 2.0 cm (5.94 and 5.91×5.47 and 5.34 log cfu/ g forage, respectively). There were no effluents losses in this trial, due to the high dry matter content of the ensiled forage (390 g/kg). The pH of the silages decreased ($P < 0.01$) along the fermentation period, with average values of 5.13 at the ensilage moment, and 3.63 after 56 d of fermentation. Among the treatments, the silage with particle

size of 0.5 cm present lower value of this variable. Particle size of 0.5 cm can reduce fermentative losses of the sugarcane silage.

Key Words: dry matter recovery, gas losses, pH

W106 A preliminary evaluation of corn silage affected by Hurricane Irene in 2011. J. M. Lim^{*1}, E. A. Cummings², H. M. Darby², and L. Kung Jr.¹, ¹University of Delaware, Newark, ²University of Vermont, Burlington.

Hurricane Irene caused severe flooding and (or) lodging of crops in the Northeastern US. The objective of this study was to evaluate the chemical composition and fermentation of corn silage harvested from 5 farms affected in Vermont. All forages had large amounts of silt on the plants at harvest. Forage was harvested 42–43 d after the hurricane and was ensiled in vacuumed and heat-sealed bags in quadruplicate per farm and allowed to ferment for 60 d at 25°C. All analyses were by wet chemistry methods. Forages averaged 34.3% DM (28.6 to 40.3%) and 6.8% CP (4.8 to 8.4%, DM basis) at harvest. Concentrations of ADF and NDF (corrected for ash) were normal. Ash content was higher than normal (4.2%, NRC, 2001) ranging from 6.2 to 24.7% (ave. 10.6%). The concentrations of Ca, P, K, and Mg were within normal ranges. High concentrations of Fe (ave. 3409 ppm, range 1256 to 4397 ppm) and Al (ave. 2211, range 1256 to 4397 ppm) were detected. Forages also contained 37%, 767% and 314% more Cu, Zn and Mn than normal, respectively. The numbers of yeasts, molds, and enterobacteria averaged 4.6, 3.8, and 6.6 log₁₀cfu/g of fresh forage, respectively. Numbers of yeasts (3.2 log₁₀cfu/g) decreased by 1 log₁₀ cfu/g of silage whereas molds and enterobacteria were not detectable after ensiling. The average pH of silages was 3.85 (3.71 to 4.19). All silages had more lactic than acetic acid with the exception of 1 farm where this was reversed. Overall, the concentrations of lactic acid, acetic acid, and ethanol were within normal ranges and averaged 3.34, 1.27, and 0.94% of DM, respectively. Butyric acid was detected in silage from only 2 farms (range 0.05 to 0.22% DM). The chemical composition and content of heavy metals in silages were similar to that of the fresh forage. Vomitoxin was detected (0.5 to 1.4 ppm) in all silage samples from 2 farms while 15-acetyl deoxynivalenol (0.9 ppm) and zearalenone (2.1 ppm) was detected in 1 out of 4 samples from 1 of these farms. Corn silage affected by Hurricane Irene generally ensiled well, but contained high levels of ash and certain minerals which when fed long-term may have negative effects on animal performance.

Key Words: corn silage, cow

W107 Feeding red clover cut at sundown and harvested as baleage did not improve milk yield in late-lactation dairy cows. N. T. Antaya^{*1}, A. F. Brito¹, R. Berthiaume², G. F. Tremblay³, N. L. Whitehouse¹, G. M. Soule¹, N. E. Guidon¹, and E. S. Fletcher¹, ¹University of New Hampshire, Durham, ²Dairy and Swine R&D Centre/ Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, ³Soils and Crops R&D Centre/Agriculture and Agri-Food Canada, Québec City, QC, Canada.

Forages cut at sundown (PM) generally yield higher concentration of nonstructural carbohydrates (NSC) than those harvested at sunup (AM). In late-lactation Holstein cows fed only forage, we showed that PM-cut alfalfa baleage increased milk yield compared with cows fed the AM-cut counterpart. In the current study, 12 multiparous and 2 primiparous Holstein cows averaging 238 DIM received a TMR containing, on a DM basis, either 65% PM- or AM-cut red clover (RC) baleage plus 35% of a common concentrate in a crossover design with 14 d for diet adaptation and 7 d for sample collection. A well established RC field was split in 2

with one half cut at sundown and the second half at sunup the next day. The PM- and AM-cut RC baleages contained (g/kg DM): 103 vs. 75.6 total ethanol soluble carbohydrates, 8.83 vs. 7.91 starch, and 112 vs. 83.5 NSC (total ethanol soluble carbohydrates + starch); baleage DM averaged 442 g/kg of fresh matter. Feeding late-lactation cows PM- vs. AM-cut RC baleage did not improve ($P > 0.05$) animal performance (see table below). However, MUN was lower ($P < 0.001$) in cows fed the PM- vs. the AM-cut RC indicating enhanced N utilization. Although cows were in late lactation, milk yield was relatively high (mean = 28 kg/d). Hence, the difference in NSC between RC baleages (28.5 g/kg DM) may not have been large enough to elicit a positive response in animal performance. Alternatively, the amount of concentrate fed may have offset the potential positive effect of the PM-cut RC baleage on improving milk yield. Research is needed to examine the interaction between forage NSC and dietary levels of concentrate.

Table 1. Milk yield and composition in cows fed TMR containing PM- or AM-cut red clover (RC) baleage

Item	TMR		SED	P > F
	PM-cut RC	AM-cut RC		
Milk yield, kg/d	27.7	28.3	0.57	0.28
DMI, kg/d	20.6	20.9	0.25	0.26
Milk fat, %	4.04	4.02	0.08	0.82
Milk fat yield, kg/d	1.10	1.10	0.04	0.89
Milk protein, %	3.26	3.27	0.02	0.67
Milk protein yield, kg/d	0.88	0.90	0.03	0.69
MUN, mg/dL	12.1	13.7	0.31	<0.001

Key Words: dairy cows, red clover, nonstructural carbohydrates

W108 The effect of feeding normal corn silage, BMR corn silage or 50:50 mixture of the two on the production performance of lactating cows. J. M. Lim^{*1}, M. C. Santos¹, M. C. der Bedrosian¹, K. E. Nestor Jr.², and L. Kung Jr.¹, ¹University of Delaware, Newark, ²Mycogen Seeds, Indianapolis, IN.

This study evaluated the feeding value of corn silage from a normal (NML, Mycogen TMF2W726, Dow AgroSciences, Indianapolis, IN), brown midrib (BMR, Mycogen F2F700) and a 50:50 mixture (MIX) of these 2 hybrids for lactating dairy cows. The NML and BMR were planted separately whereas MIX was planted in alternating rows of each hybrid. Corn was harvested at approximately 36% DM, chopped (~19 mm length), processed, and ensiled in bag silos for 6 mo. Twenty-four Holstein cows in early lactation were fed a TMR containing silage from one of the 3 corn hybrids (52% of DM) with alfalfa silage (5%), alfalfa hay (3%), and concentrate (40%) in a simultaneously replicated 3 × 3 Latin square design of experiment with 28 d periods. The chemical compositions of the corn silage were similar among hybrids except for 30-h in vitro NDF digestibility, which was lower for NML (61.48%) by 6.59 and 3.24 percentage units than BMR (68.07%) and MIX (64.72%), respectively. Milk production, percentage and yield of milk fat and protein, 3.5% FCM and ECM were not affected by treatments. Lactose was highest ($P < 0.05$) in the milk of cows fed the BMR (4.82%) silage, intermediate for NML (4.78%), and lowest for MIX (4.73%). The milk urea nitrogen (MUN) of cows fed NML (11.25 mg/dL) was higher ($P < 0.05$) than those cows fed BMR (10.27) and MIX (10.43) suggesting that there is more efficient use of dietary N for productive purposes when cows are fed BMR and MIX corn silage. Intake of DM was lower ($P < 0.05$) for cows fed BMR (26.7 kg/d) and MIX (26.9 kg/d) than NML (28.2 kg/d) silage. Feed efficiency was higher ($P < 0.05$) for the cows fed BMR (1.90) and MIX (1.84) than NML (1.73) corn silage. Growing

BMR and normal corn together produced silage with a chemical composition almost comparable to pure BMR and when fed to cows this mixture resulted in greater feed efficiency and lower milk MUN than cows fed normal silage.

Key Words: corn silage, cow, brown midrib corn

W109 Effects of an esterase-producing inoculant and chop-length on fermentation and aerobic stability of barley silage. W. Addah*^{1,2}, J. Baah¹, E. K. Okine², and T. A. McAllister¹, ¹Lethbridge Research Centre, Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada, ²Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada.

Forage chop length affects packing density of silage and thus the penetration of air into the silo face. Inoculation of silage with *Lactobacillus buchneri* inoculants has been shown to improve the fermentation and aerobic stability of cereal silages. This study investigated the effects of forage chop length and an esterase-producing inoculant on fermentation characteristics, DM loss and aerobic stability of barley silage. Whole-crop barley (*Hordeum vulgare* L.; 31% DM) was chopped to theoretical lengths of 0.95 cm (SC) or 1.90 cm (LC) and ensiled with or without an inoculant containing esterase-producing *L. buchneri* LN4017, and *Lactobacillus plantarum* LP7109 and *Lactobacillus casei* (2.8×10^5 cfu/g forage) in mini silos. Silos were opened after 64 d of ensiling for determination of fermentation characteristics and assessment of aerobic stability over an 8-d period. Thermocouples were embedded in the d-64 silages to measure temperature over the period of assessment of aerobic stability. Data were analyzed by the mixed procedure of SAS in a 2×2 factorial design. Inoculation decreased ($P = 0.01$) pH in SC (pH = 3.87) but not LC (pH = 4.02) silage. Inoculated LC had higher ($P = 0.01$) acetic acid concentration (1.8% DM) compared with the inoculated SC (1.4% DM) silage. Lactic acid concentration was also higher ($P = 0.01$) in the LC (8.2% DM) than in SC (6.7% DM) silage regardless of inoculation. Lactic: acetic acid ratio was lower ($P = 0.01$) with inoculation of LC (4.6) compared with the ratio in the SC (4.5) silage. Regardless of chop length, inoculation increased ($P = 0.01$) lactic acid bacteria and decreased ($P = 0.03$) yeast populations. Neither chop length, inoculation nor their interaction affected silage DM losses. Short-chop silage remained stable during 8 d of aerobic exposure; however, the inoculated LC silage was stable for 7 d compared with only 4 d without inoculation. In both lengths of chop, the inoculant caused shifts in silage fermentation and lengthened the duration of aerobic stability in LC silage compared with the SC.

Key Words: aerobic stability, silage chop length, barley silage

W110 Effects of applying bacterial inoculant with different shooting height on fermentation quality of barley silage. D. H. Kim*¹, H. J. Lee¹, S. M. Amanullah², S. C. Kim², Y. M. Song³, H. Y. Kim³, and S. B. Kim⁴, ¹Division of Applied Life Science (BK21), Gyeongsang National University, Jinju, Gyeongsangnamdo, South Korea, ²Department of Animal Science (Inst. Agric. Life Sci.), Gyeongsang National University, Jinju, Gyeongsangnamdo, South Korea, ³Department of Animal Resource Technology, GNUST, Jinju, Gyeongsangnamdo, South Korea, ⁴Dairy Science Division, NIAS, Cheonan, Chungnam, South Korea.

This study was conducted to evaluate the effect of bacterial inoculant with the different shooting height on fermentation quality of barley silage. Barley forage (Yuyeon hybrid) was grown at Animal Research Unit, Gyeongsang National University, Jinju, South Korea. Barley forage

(500 kg) was harvested at 25% DM with 2 different shooting heights (5 cm and 15 cm), chopped 5 cm length and divided 2 piles. One half of barley forage at each shooting height was used for no inoculant treatment and the other for inoculant treatment. The inoculant was applied at 1.2×10^3 cfu/g of forage (*L. plantarum*). The experiment was conducted in a 2×2 factorial design with 5 replications. Barley forage was ensiled into 10 L bucket silo for 2, 5, 7, 28, 49 and 100-d durations. Dry matter, CP, and NDF concentrations of barley forages at 5 cm and 15 cm of shooting height were 26.1, 7.03 and 58.4% vs. 24.9, 8.92 and 60%, respectively. Inoculant increased ($P = 0.001$) DM (20.2 vs. 19.2%) of barley silage ensiled for 100-d, but decreased ($P < 0.005$) CP, crude ash, NDF and ADF concentrations (8.1 vs. 8.8%, 7.7 vs. 8.2%, 55.1 vs. 58.4% and 35.8 vs. 38.9%, respectively). Increased shooting height increased ($P < 0.001$) CP concentration (9.2 vs. 7.7%), whereas decreased ($P < 0.05$) DM, crude ash, NDF, ADF and hemicellulose concentrations (19.4 vs. 20.0%, 7.7 vs. 8.2%, 54.6 vs. 58.8%, 35.8 vs. 38.8% and 18.8 vs. 20.1%, respectively). Yeast was decreased (9.5 vs. 7.0 \log_{10} cfu/g, $P < 0.001$) by increasing shooting height. Increased shoot height in absence of inoculants had the decrease effects ($P < 0.05$) on acetate concentration (6.0 vs. 3.7%) and mold (5.6 vs. 4.5 \log_{10} cfu/g), but the increase effects of lactate concentration (2.8 vs. 5.9%) and lactate to acetate ratio (0.5 vs. 1.6). However these measurements were not affected by shooting height with inoculant. Gel electrophoresis analysis and band mass after PCR amplification of DNA indicated higher *L. plantarum* in barley silage with applied inoculant and increased shooting height. Therefore, applying bacterial inoculant and increased shooting height can improve the fermentation quality of barley silage.

Key Words: barley silage, inoculant, shooting height

W111 Effects of bacterial inoculant and shoot height on fermentation quality of barley silage. H. J. Lee*¹, D. H. Kim¹, S. M. Amanullah², S. C. Kim², Y. M. Song³, H. Y. Kim³, and S. B. Kim⁴, ¹Division of Applied Life Science (BK21), Gyeongsang National University, Jinju, Gyeongsangnamdo, South Korea, ²Department of Animal Science (Inst. Agric. Life Sci.), Gyeongsang National University, Jinju, Gyeongsangnamdo, South Korea, ³Department of Animal Resource Technology, GNUST, Jinju, Gyeongsangnamdo, South Korea, ⁴Dairy Science Division, NIAS, Cheonan, Chungnam, South Korea.

This study was carried out to determine the effect of applying inoculant and shoot height on fermentation quality of barley silage. Youngyang hybrid barley forage was grown at Animal Research Unit, Gyeongsang National University, Jinju, South Korea, and harvest at 27% DM with 2 different shoot heights (5 cm and 15 cm). Approximate 500kg of barley forage with 5cm or 15cm shoot heights were chopped 5 cm length and divided 2 piles for with or without inoculant application at 1.2×10^3 cfu/g of forage (*L. plantarum*). A 2 (inoculant) \times 2 (shoot height) factorial design with 4 replications was used in this study. Barley forage was ensiled into 10 L mini silo (3 kg) for 2, 7 and 100 d fermentations. Before ensiling, barley forages of 5 cm and 15 cm shoot heights had 25.7 vs. 28.6% of DM and 54.6 vs. 55.5% of NDF, respectively. After 100 d of fermentation, ash content decreased by applying inoculant (2.3 vs. 2.5%, $P = 0.021$) or increased shoot height (2.3 vs. 2.6%, $P = 0.008$), while ether extract (3.7 vs. 2.9%, $P = 0.069$) tended to increase with increased shoot height. By increase of shoot height, crude protein concentration decreased (8.8 vs. 8.2%, $P < 0.05$) in without inoculant, but increased (8.2 vs. 9.0%, $P < 0.05$) in with inoculant. The concentrations of ammonia N (0.32 vs. 0.23%, $P = 0.001$) and ammonia N of total N (23.4 vs. 16.9%, $P = 0.004$) were increased by applying inoculant, while propionate concentration (0.48 vs. 0.71%, $P = 0.004$) was decreased with increase of shoot height. Lactate concentration (2.9 vs. 4.9%) and lactate

to acetate ratio (0.5 vs. 1.1) were increased ($P < 0.05$) by increased shoot height and applied inoculant, but no effects on them by increased shoot height and without inoculant. Gel electrophoresis and band mass after PCR amplification of DNA had shown higher *L. plantarum* in barley silage by inoculant application and increase of shoot height. These results indicate that Youngyang hybrid barley silage has better quality without *L. plantarum* irrespective of shoot height.

Key Words: barley forage, silage quality, fermentation indices

W112 Effects of inoculant blends on emissions of volatile organic compounds, oxides of nitrogen, carbon dioxide, ammonia, and dry matter losses in alfalfa silage. R. B. Franco*¹, J. A. McGarvey², D. H. Putnam³, P. G. Green⁴, and F. M. Mitloehner¹, ¹Department of Animal Science, University of California, Davis, ²United States Department of Agriculture, Agricultural Research Service, Albany, CA, ³Department of Plant Sciences, University of California, Davis, ⁴Department of Civil and Environmental Engineering, University of California, Davis.

The San Joaquin Valley (SJV) in Central California exhibits high ground-level ozone pollution that may affect human, animal, and plant health. Silage and other feedstuff were identified as a major source for volatile organic compounds (VOCs) and nitrogen oxides (NO_x) which could be a contributor to ozone formation in this area. Gaseous losses from silages also affect feed quality and silage dry matter (DM) losses of 20–30% have been widely reported to occur in the SJV. These DM losses include gaseous losses of VOCs and NO_x but also carbon dioxide (CO₂) and ammonia (NH₃). Microbial inoculants are utilized in silage to promote effective fermentation, and thus could affect the amount and species of gases emitted, dry matter losses from original material ensiled, and subsequently, animal performance. This study quantified the different VOCs, NO_x, (CO₂), (NH₃) emitted from alfalfa silage (*Medicago sativa* L.) and DM losses after microbial inoculation for 60 d. Twenty-five mini-silos (22 L) were built and used in a repeated measures design over time. Five mini-silos were assigned to 5 treatments: (X) control, (A) heterofermentative, (B) homofermentative 1, (C) a mix of homofermentative and heterofermentative microbes, and (D) homofermentative 2. Emissions were measured using a photoacoustic gas monitor and a NO/NO₂/NO_x analyzer, using 5 L Teflon bags for gas collection. Concentrations of NO_x, predominantly nitric oxide ($7.35 \pm 1.65 \mu\text{g NO}_x\text{-N g DM silage}^{-1}$) on treatment C were measured (p -value = 0.046). Ethanol and methanol were also detected but with no differences across treatments. No differences in DM losses were observed across treatments, however differences were observed over time (p -value = 0.03). Further studies in quantification and monitoring of these emissions are critical for assessment and therefore response to the specific needs of the air quality in the SJV.

Key Words: NO_x, alfalfa silage, alcohols

W113 Screening of bacteriocinogenic lactic acid bacteria from tropical legume silage. M. Silva, H. Mantovani, O. Pereira,* C. Moraes, A. Ribon, and W. Souza, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil.

Ensiling has been used worldwide to preserve the nutritional quality of field crops used as animal feeds. The objective of this work was to isolate and characterize bacteriocinogenic lactic acid bacteria (LAB) during the ensiling of Campo Grande *Sylosanthes* (a mixture of *Stylosanthes capitata* and *S. macrocephala*). Mini-silos made of plastic bags and containing 600 g of chopped forage added with increasing amounts of citrus pulp were used in this study. Samples (25 g) harvested at d 1,

7, 14, 28 and 56 of fermentation were serially diluted in Na-phosphate buffer and plated in selective MRS media containing purple bromocresol. Colonies of gram-positive bacteria that produced acid and were catalase negative were picked for further characterization. Antimicrobial activity was determined against *Listeria monocytogenes* ATCC 7644. The genetic diversity of selected isolates was determined by BOX-PCR fingerprinting and identification was achieved by phenotypic characterization and sequencing of the 16S rDNA. Two hundred and 50 6 cultures were isolated during the ensiling process and 83% (n = 214) of the isolates showed some antagonist activity against *L. monocytogenes*. From these, 22 isolates with simple growth requirements were grouped by BOX-PCR in 2 separate clades, which distinguished the isolates by the period of ensiling (first day and 14 d of fermentation). The fermentation pattern of 49 carbohydrates and the sequencing of the 16S rDNA indicated that the isolates with greater ability to compete during ensiling (n = 8) belonged to the species *Pediococcus pentosaceus*, *Pediococcus acidilactici* and *Lactobacillus plantarum*. The antimicrobial activity of acidic cell-free extracts obtained from *P. pentosaceus* MP6.16, *P. acidilactici* MP10.4 and *P. acidilactici* MP10.6 was sensitive to proteinases, indicating its proteinaceous nature. Based on the inhibitory activity against other gram-positive bacteria (e.g., *Staphylococcus*, *Micrococcus*, *Streptococcus*) and their simple growth requirements, the isolates obtained in this study could be tested as inoculants for legume silages. Financial support by CNPq and FAPEMIG.

Key Words: antimicrobial activity, *Listeria monocytogenes*, lactic acid bacteria

W114 Chemical composition and fermentation profile of *Brachiaria brizantha* and Campo Grande *Stylosanthes* mixed silages. J. P. Rigueira, O. Pereira,* K. Ribeiro, A. Cezário, and W. Souza, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.

The aim of this study was to evaluate the chemical composition, fermentation profile and dry matter recovery in *Brachiaria* grass silage with increasing levels of Campo Grande *Stylosanthes* (0, 10, 20 and 30%), with and without bacterial inoculant. The *Brachiaria* was harvested at 70 d of regrowth and the *Stylosanthes* at the pre-flowering stage. The inoculant used was Sil All C4 (Alltech Brazil). The material was ensiled in laboratory silos of 20 kg capacity, equipped with Bunsen valves. A 4 × 2 factorial arrangement of treatments (4 levels of *Stylosanthes* × with and without inoculant) was used, in a completely randomized design, with 4 replications. There was interaction effect ($P < 0.05$) of *Stylosanthes* levels and inoculants on dry matter (DM) content, effluent losses, dry matter recovery and mold and yeast populations. The DM content of silage with and without inoculant increased linearly with increasing levels of *Stylosanthes* in the silages. The crude protein (CP) content increased linearly while the neutral detergent fiber (NDF) content decreased linearly with increasing levels of *Stylosanthes* in the silages. The pH and NH₃-N content were affected only by *Stylosanthes* levels. There were effects ($P < 0.05$) of inoculant and levels of *Stylosanthes* on LAB populations. The DM recovery increased linearly with increasing levels of *Stylosanthes* in the silage without inoculant. However, in inoculated silage the maximum recovery of DM was found in silages containing 17% of *Stylosanthes*. We concluded that the Campo Grande *Stylosanthes* improves the nutritive value and reduces the losses of DM in mixed silages of *Brachiaria* and *Stylosanthes*. Financial support by CNPq and Fapemig

Key Words: ADF, NDF, pH

W115 Feedtech CustomChop F-20 enhances the fermentation characteristics of elephant grass (*Pennisetum purpureum*) after 45 d of ensiling. A. A. Rodríguez*¹, L. C. Solórzano², and T. Hemling³, ¹University of Puerto Rico, Mayagüez, PR, ²Chr. Hansen, Milwaukee, WI, ³DeLaval Manufacturing, Kansas City, MO.

This study determined the ensiling characteristics and aerobic stability of *Pennisetum purpureum* (PP) fermented with or without a microbial additive containing the lactic acid-producing bacterial strains (LAPBI) *Lactobacillus plantarum* MiLAB 393; *Pediococcus acidilactici*, *Lactococcus lactis*, and *Enterococcus faecium*. Forage (23.43% DM) was chopped at 2.5 cm and assigned to 1 of the 2 treatments (TRT). Additive was added to weighed portions of PP and packed into PVC micro-silos (1.8 kg) to ferment for 45 d at 25 to 27°C. The LAPBI were applied to the forage at a rate of 2×10^5 cfu/g of fresh material. Five silos from each TRT were analyzed for pH, populations of lactic acid-producing bacteria (LAPB), fermentation products, and DM losses. Statistical analysis was a completely randomized design with a 2 additives by 2 d of ensiling (0 and 45) factorial arrangement of TRT. Tukey-test was used for mean separation. Temperature was monitored for aerobic stability determination at 29 6 h intervals (168 h total) in 5 samples from each TRT (1000 g). Statistics were performed as a split plot design with a 2 additives by 29 times as repeated measures factorial arrangement using silos replicates. Treated silage had lower ($P < 0.05$) pH and higher LAPB population than control (3.74 vs. 4.16 and 6.78 vs. 6.01 cfu/g, respectively). Lactic acid % and lactic acid:acetic acid ratio were higher ($P < 0.05$) in PP fermented with LAPBI than control (3.47 vs. 2.24 and 6.61 vs. 1.56, respectively). Acetic, butyric, and propionic acid % were lower ($P < 0.005$) in treated PP than control (0.71 vs. 1.47, 0.00 vs. 0.09, and 0.00 vs. 0.47, respectively). Forage treated with LAPBI also had a numerically lower $\text{NH}_3\text{-N}/\text{total-N}$ ratio and DM losses associated with the fermentation process than untreated silage. In summary, addition of the LAPBI improved the fermentation characteristics of PP. Forage fermented with or without the microbial additive resulted in silage stable to aerobic conditions.

Key Words: *Pennisetum purpureum*, microbial inoculant, fermentation

W116 Intake and total apparent digestibility of nutrients of corn and *Stylosanthes* silages in diets for sheep. L. Silva, O. Pereira,* K. Ribeiro, S. Valadares Filho, and T. Silva, *Federal University of Vicosa, Vicosa, Minas Gerais, Brazil.*

The Campo Grande *Stylosanthes*, native from Brazil, is one of the most important legumes of tropical and subtropical regions due to adaptation to low soil fertility. The objective of this study was to evaluate the nutrient intake and total apparent digestibility of corn and *stylosanthes* silages in diets for sheep. The experimental diets consisted of: 1- corn silage and concentrate (CS+C), 2- *Stylosanthes* silage and concentrate (StS+C) and 3- *Stylosanthes* silage exclusive (StS). The concentrate represented 50% of total DM of diets 1 and 2. Diets were formulated to be isonitrogenous, 12.0% CP on DM basis, similar to the content found in StS, 11.7% CP. The concentrate consisted of corn, soybean meal and a mixture of urea and ammonium sulfate 9:1 to adjust the CP content of diets due to differences in the CP content of silages. Twelve crossbred Santa Ines sheep, weighing on average 32.2 kg BW, were allotted in 4 3x3 Latin squares. The animals were kept in individual pens with protected feeders and wateriers. Each experimental period lasted 16 d, being 10 d for adaptation and 6 for collection of data and sample. It was performed 4 d of total collection of feces through tailored bags to the animals. The data were subjected to statistical analysis using the SAS. Intake of DM, CP and NDF was lower ($P < 0.05$) for animals fed StS compared with that observed for StS+C and CS+C which were similar

(Table 1). Intake of EE was lower ($P < 0.05$) for animals fed CS+C compared with other treatments. Diets containing CS or StS, supplemented with concentrate can be considered nutritionally equivalent. Financial support by CNPq and Fapemig.

Table 1. Average daily intake and total apparent digestibility coefficients of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and ether extract (EE) in the diets

Item	Intake (g/d)			Digestibility(%)		
	CS+C	StS+C	StS	CS+C	StS+C	StS
DM	1,047.3 ^a	958.9 ^a	557.9 ^b	74.1 ^a	64.3 ^b	40.1 ^c
CP	112.6 ^a	110.3 ^a	62.1 ^b	67.9 ^a	60.8 ^b	51.3 ^c
NDF	398.3 ^a	434.5 ^a	339.7 ^b	61.53 ^a	53.0 ^b	42.6 ^c
EE	11.9 ^b	13.5 ^{ab}	16.3 ^a	71.85 ^a	63.7 ^b	74.5 ^a

^{a-c}Means followed by the same letter in the row for intake and digestibility did not differ ($P > 0.05$) by Tukey's test.

Key Words: crude protein, dry matter, legume silage

W117 Condensed tannins concentrations of prairie legume forages at different phenological stages. Y. Li^{1,2}, A. D. Iwaasa*¹, Y. Wang³, L. Jin³, and G. Han², ¹Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, Swift Current, Saskatchewan, Canada, ²Colleges of Ecology and Environment Science, Inner Mongolia Agricultural University, Huhhot, China, ³Lethbridge Research Center, Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada.

Although studies have shown that condensed tannins (CT) at appropriate concentration improves protein utilization and prevents bloat in ruminant animals, information on CT content in different phenological stages and different portions of forages growing in North America prairie is still lacking. Objective of this study was to determine the CT concentration in legume forages at different phenological stages and plant portions. Whole plant samples of purple prairie clover (*Dalea purpurea* Vent., PPC), white prairie clover (*Dalea candida* Michx. ex Willd, WPC), sainfoin (*Onobrychis viciifoliov* Scop.) and Canadian milkvetch (*Astragalus Canadensis* L., CMV) were collected in 2011 from replicated small plots (n = 4) at different phenological stages: flowering and seed maturity stage. The samples were manually separated into leaf, stem and floral/seed pod plant portions depending on the phenological stage. Samples were freeze-dried, ground (1 mm) and analyzed CT by a modified Butanol-HCL procedure. Measurement of CT for every plant portion by phenological stage was done by legume forage and Proc Mixed procedure of SAS was used to analyze data. Differences ($P < 0.05$) were observed between each plant portions for each phenological stage for PPC and WPC. Condense tannins were highest for floral/seed pod > leaf > stem. The highest average CT contents for PPC and WPC at flowering and floral/seed pod were 161.63 ± 5.58 g kg^{-1} DM and 149.53 ± 4.03 g kg^{-1} DM, respectively. For sainfoin the CT contents were different ($P < 0.05$) between plant portions and phenological stages with the leaf having the highest contents (78.41 ± 1.70 g kg^{-1} DM) and the stem having the lowest content (10.17 ± 0.48 g kg^{-1} DM). With the exception of the seed pod, no CT contents were detected for CMV in the leaf, stem or flower portions at any phenological stage. Results demonstrate that CT levels can be quite variable among legumes and were dependent upon phenological stage and plant portion. Time of grazing of these CT legumes is important to optimize ruminant performance and productivity.

Key Words: condensed tannins, legume forage, leaf, stem, floral/seed pod

W118 Mixing purple prairie clover with alfalfa reduced alfalfa N transforming to ammonia-N. L. Jin^{1,2}, Z. Xu¹, A. D. Iwaasa³, Y. G. Zhang², M. P. Schellenberg³, T. A. McAllister¹, and Y. Wang^{*1}, ¹AAFC, Lethbridge, AB, Canada, ²Northeast Agricultural University, China, ³SPARC-AAFC, Swift Current, SK, Canada.

Although mixing condensed tannin (CT)-containing forage with alfalfa (Alf) reduces protein degradation it is not known if this is due to the binding of CT to Alf protein. The objective of this study was to assess the effects of purple prairie clover (PPC) CT on N transformation of Alf during ruminal fermentation. Alfalfa was grown in a greenhouse in a nutrient solution containing ¹⁵N labeled ammonium sulfate and harvested at the vegetative growth stage. Native PPC was harvested at the full-flower and early seeding stage. Both forages were freeze-dried, ground (1 mm) and then mixed in ratios (DM basis) of 0:100, 25:75, 50:50, 75:25 and 100:0. The forage mixtures were incubated in mixed rumen batch cultures in serum vials supplemented with or without polyethylene glycol (PEG) for 6, 12, 24 and 48 h. Gas and methane production, VFA, NH₃-N and NH₃-¹⁵N were determined. Effect of CT was assessed by comparing differences in fermentation parameters between incubations with and without PEG. Data were analyzed statistically by ANOVA as a 5 × 2 factorial design using the MIXED procedure of SAS. A forage × PEG interaction was observed ($P < 0.05$) for gas production (ml/g DM), NH₃-N (mg/g DM) and NH₃-¹⁵N (μg/g Alf ¹⁵N) accumulation. Inclusion of PEG did not affect CH₄ or VFA production in any of the forage mixtures. However, gas production and accumulation of NH₃-N and NH₃-¹⁵N were linearly ($P < 0.05$) increased (6, 12, 24 and 48 h) by PEG as the proportion of PPC increased in the forage mixture. The proportion Alf ¹⁵N transformed to NH₃-¹⁵N was reduced ($P < 0.001$) by PPC CT for 50:50 and 25:75 Alf-PPC mixtures at 12, 24, 48 but not 6 h of incubation. This indicates that PPC CT reduced transformation of Alf N to NH₃-N and that mixing PPC with Alf has the potential to improve the utilization of Alf protein by ruminants.

Key Words: condensed tannins, alfalfa, N transformation

W119 Effect of sainfoin condensed tannins on the N transformation of alfalfa forage preserved as silage. Y. Wang,* Z. Xu, S. Acharya, and T. A. McAllister, AAFC, Lethbridge, AB, Canada.

Our previous study demonstrated that ensiling fermentation was improved and protein degradation was reduced by mixing alfalfa and sainfoin during the ensiling process, presumably due to the presence of condensed tannins (CT) in sainfoin. The objective of this study was to assess the effects of sainfoin CT on the N transformation of alfalfa during ensiling. Freshly harvested vegetative alfalfa grown in greenhouse with nutrient solution containing ¹⁵N labeled ammonium sulfate, and pre-buds-stage sainfoin from field plots were chopped and mixed manually to the ratio of (alfalfa:sainfoin; DM basis) 100:0, 75:25, 50:50 and 25:75. Each mixture was made in 6 portions and half of them were sprayed with polyethylene glycol (PEG) to deactivate CT. The PEG and non-PEG treated forages were then ensiled in laboratory silos. At d 7, 14 and 74 of the ensiling, triplicate silos were opened and the content was processed for laboratory evaluation. After 74-d ensiling, increasing proportion of sainfoin in the mixtures increased concentrations of lactic acid (L; $P < 0.001$) and total VFA (Q, $P < 0.001$), resulting in decreased silage pH (L; $P < 0.001$). Inclusion of PEG did not affect silage pH or concentration of VFA, but increased ($P < 0.01$) concentration of lactic

acid. Interactive effects of forage × PEG were observed ($P < 0.05$) in concentrations of NPN (mg/g total N), ¹⁵NPN (μg/g alfalfa N), NH₃-N (mg/g total N) and NH₃-¹⁵N (μg/g alfalfa N). The concentrations of NPN and NH₃-N were linearly increased ($P < 0.05$) by PEG as the proportion of sainfoin increased. The inclusion of PEG also linearly increased ($P < 0.05$) concentrations of ¹⁵NPN and NH₃-¹⁵N as the proportion of sainfoin increased. The results demonstrated that co-ensiling sainfoin and alfalfa improved ensiling fermentation in laboratory silos and alfalfa protein degradation was decreased by sainfoin CT. Co-ensiling sainfoin and alfalfa has the potential to reduce alfalfa protein degradation and improve the silage quality.

Key Words: condensed tannins, alfalfa, silage

W120 Effect of application rate of a fibrolytic enzyme product on in vitro ruminal fermentation of three low-quality substrates.

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The effects of a fibrolytic enzyme product (Dyadic Xylanase PLUS, Dyadic Inc. USA) on the in vitro ruminal fermentation of 3 low-quality forages (rice straw, corn stover and grass hay) were investigated using batch cultures of mixed ruminal microorganisms. Five different treatments were tested: 0X (control), 0.5X, 1X, 4X and 10X (where 1X was the manufacturer recommended dose, 20 mg/g DM). Enzymes were applied directly onto the forages 24 h before incubation with buffered ruminal fluid at 39°C for 9 h. Four incubation runs were performed on different days. Gas production was measured at 3, 6, 9 h, and the main fermentation parameters were determined at the end of the incubation. Five concentrations of enzyme, 3 substrates, and the interaction of enzyme × substrate were included in the model as fixed effects, whereas incubation day was considered as a random effect. There were enzyme × substrate interactions for all the parameters measured, indicating different effects on each feed. All doses of enzyme product increased ($P < 0.05$) gas production after 3, 6 and 9 h of incubation for corn stover and grass hay, whereas only 10X increased ($P < 0.05$) gas production at 3 and 6 h for rice straw, compared with the control. All doses stimulated ($P < 0.05$) gas production after 9 h of incubation for the 3 substrates. Dry matter disappearance increased ($P < 0.05$) with doses 4X and 10X for the 3 substrates. Doses 0.5X, 1X and 4X decreased ($P < 0.05$) NH₃ concentrations for the 3 substrates, but 10X had no effect ($P > 0.05$). Enzyme treatment increased ($P < 0.05$) total VFA production to 116, 120, 131 and 177% of control values for 0.5X, 1X, 4X and 10X, respectively, for grass hay, to 147, 173, 190 and 268% of control values for corn stover, and 125, 149, 160 and 282% of control values for rice straw. Acetate:propionate ratio decreased ($P < 0.05$) in grass hay and maize stover treated with any dose of the enzyme product, but in the case of rice straw, 0.5X, 1X and 4X doses increased ($P < 0.05$) this ratio and 10X decreased ($P < 0.05$) it, compared with the control. The results indicate that the pre-treatment of these low-quality forages with a wide range of doses of the fibrolytic enzyme has a positive effect on ruminal fermentation and the enzyme product is a good candidate to improve their digestibility.

Key Words: xylanase, low-quality forages, In vitro ruminal fermentation