Ruminant Nutrition: Beef: Additives and Supplements

282 The effect of Bovamine on feedlot performance of finishing cattle: A meta-analysis. K. J. Hanford*[1], W. M. Kreikemeier[2], and D. R. Ware[2], *[1]Department of Statistics - UNL, Lincoln, NE, [2]Nutrition Physiology Co. LLC, Overland Park, KS.*

A meta-analysis of the effect of Bovamine (Nutrition Physiology Co., LLC) on performance of finishing cattle was conducted. Bovamine contains a patented combination of a lactic acid-producing bacterium (Lactobacillus acidophilus NP51) and a lactic acid-utilizing bacterium (Propionibacterium freudenreichii NP 24). Summary data from 18 feeding trials comparing control vs Bovamine were included. PROC GLIMMIX (SAS Institute) was used with a model including the fixed effect of treatment (Control vs Bovamine), a covariate of initial body weight, a treatment by covariate interaction and a random study effect. Any non-significant ($\alpha > 0.05$) interaction or covariate terms were dropped from the final model. Meta-analytical methods that weight responses by size of the study and precision of result were used. A subset analysis of those studies that included a corn processing by-product was also performed (7 trials). Initial body weight was significantly linearly associated with hot carcass weight (HCW) in the full analysis (b = 0.3457). DMI was not different between Bovamine and Control (95% CI = −0.010 to 0.116, $P = 0.0949$). Cattle fed Bovamine had higher ADG by 0.041 kg (95% CI = 0.027 to 0.054, $P < 0.0001$) and HCW by 3.51 kg (95% CI = 2.38 to 4.65, $P = 0.0001$) and lower feed to gain ratio (F:G) by −0.09 (95% CI = −0.132 to −0.049, $P = 0.0002$). Similar results were found for the analysis of studies that included feeding a corn processing by-product. DMI was not different between Bovamine and Control (95% CI = −0.023 to 0.177, $P = 0.1087$). Cattle fed Bovamine had higher ADG by 0.031 kg (95% CI = 0.010 to 0.051, $P = 0.0104$) and HCW by 4.32 kg (95% CI = 2.35 to 6.29, $P = 0.0025$) and lower F:G by −0.07 (95% CI = −0.130 to −0.013, $P = 0.0239$). These results quantify the effects of Bovamine on performance of feedlot cattle.

Key words: meta-analysis, feedlot cattle, direct fed microbial

283 Effects of Min-Ad on growth performance and carcass characteristics of finishing steers. J. O. Wallace*[1], M. S. Brown[1], D. D. Simms[2], C. W. Coufal[1], C. L. Maxwell[1], J. C. Simroth-Rodriguez[1], K. J. Kraich[1], and S. L. Thomas[1], *[1]West Texas A&M University, Canyon, [2]Min-Ad Inc., Amarillo, TX.*

Crossbred steers (n = 280; initial BW = 368 ± 10.7 kg) were used to evaluate the effects of feeding wet corn distillers grains (WCDG) and a commercial source of calcium–magnesium carbonate (MA, Min-Ad Inc., Amarillo, TX) on growth performance and carcass characteristics. Cattle were adapted to a common finishing diet, blocked by BW, implanted with Revalor-IS, and assigned to treatments of MA supplementation (0 or 1% of diet DM) and WCDG concentration (0 or 15% of diet DM). Cattle were housed in 28 soil–surfaced pens. Diets were fed twice/d for 169 d and cattle were reimplanted with Revalor–200 on d 48. Interactions existed for both shrunk initial BW and LMA ($P = 0.02$ and 0.04 respectively); however, there were no effects of either MA or WCDG on either variable ($P \geq 0.26$). Cattle fed MA consumed less feed and had lower ADG on a live basis (1.47 vs. 1.52 kg/d); SE = 0.061) and carcass-adjusted (CA) ADG resulting in a lower final BW and CA final BW ($P \leq 0.02$) than cattle not fed MA. Cattle fed MA had lighter HCW ($P = 0.03$); however, their marbling scores were higher ($P = 0.04$) than cattle not fed MA. Cattle fed WCDG consumed more feed and had higher ADG and CA ADG ($P \leq 0.06$) than cattle not receiving WCDG, resulting in heavier final BW and CA final BW, and improved F:G ($P \leq 0.07$) for cattle fed WCDG. Feeding WCDG also increased HCW, although dressing percent was decreased by feeding WCDG ($P = 0.07$ and 0.05, respectively). An interaction for USDA average yield grade (YG) ($P = 0.13$) was evident; however, there were no effects of either MA or WCDG ($P \geq 0.11$) on USDA average YG and these data followed the same numeric trend as BF thickness. No interactions existed for YG or quality grade distributions. Feeding MA increased the percentage of premium carcasses ($P = 0.07$) and feeding WCDG decreased the percentage of YG 2 carcasses ($P = 0.03$). There were no differences in water consumption by treatment. Results suggest that there are no performance benefits from including MA in the diet at 1% of DM under the conditions of this study; however, supplementing an SFC-based diet with 15% WCDG on a DM basis may improve carcass-adjusted performance.

Key words: feedlot cattle, wet corn distillers grains, Min-Ad

284 Ractopamine hydrochloride reduces urinary nitrogen excretion of both implanted and non-implanted finishing beef cattle. M. M. Kappen*, J. Ham, H. Han, and S. L. Archibeque, *Colorado State University, Ft. Collins.*

The effects of ractopamine hydrochloride (RAC) and a steroidal implant (IMP), on whole body N metabolism were evaluated in 24 Hereford × Angus steers (BW 554.4 ± 26.8 kg). The experimental design was a completely randomized block design with a 2 × 2 factorial arrangement of treatments. Factors included: 1) RAC (0.0 or 400 mg × hd-1 × d-1) and 2) IMP (0.0 or 200 mg trenbolone acetate and 28 mg of estradiol benzoate). Steers were housed in individual pens and allowed ad libitum access to feed and water throughout the experiment. Steers were acclimated to the metabolism barn by bringing in, tying and currying for 12 d before the initiation of the experiment. Once cattle had been implanted for 48 d and had received RAC for 21 d a nutrient balance study was conducted for 6 d. An IMP × RAC interaction tended ($P < 0.09$) to exist for DMI. Implanted steers receiving RAC tended to have lower DMI compared with non-IMP steers receiving RAC as well as IMP steers not receiving RAC. N intake ($P > 0.11$) and fecal N ($P > 0.18$) were not different due to treatment, yet numerically reflected the trend noted for DMI. Urinary N excretion was decreased by feeding RAC ($P < 0.01$). There tended ($P < 0.08$) to be an IMP × RAC interaction for urinary N excretion. Implanted steers receiving RAC tended to have less urinary N than steers receiving an implant only. Similarly, urine urea N excretion was decreased by RAC treatment ($P < 0.02$) and excretion was greater in steers that had also received IMP (IMP × RAC interaction; $P < 0.08$). Overall N retention was not affected by treatment ($P > 0.14$). These results indicate that urinary N excretion may be reduced by incorporating RAC according to labeled usage during the final phase of the finishing period. However, further studies will be required to elucidate the potential interactions of RAC with implant status and various types of implants.

Key words: ractopamine hydrochloride, trenbolone acetate, urinary nitrogen

285 Impact of sorting prior to feeding zilpaterol hydrochloride on feedlot performance and carcass characteristics of yearling steers. E. M. Hussey*[1], G. E. Erickson[1], W. A. Griffin[1], B. L. Nuttleman[1], T. J. Klopfenstein[1], and K. J. Vander Pol[2], *[1]University of*

Nebraska-Lincoln, Lincoln, [2]Intervet/Schering-Plough Animal Health, De Soto, KS.

Crossbred yearling steers (342 ± 10 kg initial BW) were assigned randomly to pens with 3 arrival blocks (25 steers/pen, 40 pens) to evaluate sorting and feeding zilpaterol on feedlot performance and carcass characteristics. Five treatments included an unsorted negative control (-CON), unsorted zilpaterol fed positive control (+CON); and 3 treatments where the heaviest 20% within the pen were sorted and marketed 28 d early and the remaining 80% were fed zilpaterol. The 20% were identified at the beginning (EARLY), 100 d from slaughter (MIDDLE), or 50 d from slaughter (LATE) by weighing individuals. Because of sorting, remaining steers in sorted treatments were fed 14 d longer than -CON and +CON. Steers fed zilpaterol were fed Zilmax at 8.3 mg/kg DM for 20 d followed by a 3 d withdrawal. Data were analyzed using Proc Mixed using a protected F-test and 3 preplanned contrasts. Steers fed +CON were 12 kg heavier ($P < 0.01$) than steers fed -CON. Steers sorted EARLY, MIDDLE, and LATE were 33, 25, and 32 kg heavier ($P < 0.01$) than -CON, respectively. Gain and G:F were greater ($P \leq 0.03$) for +CON than -CON, but not different between +CON and sorted treatments. Steers fed +CON had 15 kg greater HCW than -CON. Steers sorted EARLY, MIDDLE, and LATE had 28, 24, and 24 kg heavier ($P < 0.01$) HCW than -CON, respectively. Carcass weight SD was greater ($P = 0.01$) for +CON than -CON, but not different ($P = 0.16$) between -CON and zilpaterol sorted treatments. Percentage of overweight carcasses was greater ($P \leq 0.05$) in sorted treatments than -CON. Fat depth was lower ($P = 0.02$) in +CON than -CON, but not different between -CON and zilpaterol sorted treatments. LM area was greater ($P < 0.01$) in +CON and zilpaterol sorted treatments than -CON, and similar ($P = 0.57$) for all treatments fed zilpaterol. Marbling score was lower ($P < 0.01$) for +CON than -CON, but not different ($P = 0.60$) between -CON and zilpaterol sorted treatments. Feeding Zilpaterol in combination with sorting to identify heavy carcasses increased HCW without increasing variation and equalized marbling score compared with a negative control.

Key words: feedlot cattle, sorting, zilpaterol

286 Effect of feeding Micro-Aid in diets containing wet distillers grains plus solubles to finishing cattle on performance and nutrient mass balance fed during the summer. A. J. Doerr*[1], B. L. Nuttelman[1], G. E. Erickson[1], T. J. Klopfenstein[1], W. A. Griffin[1], and M. J. Rincker[2], *[1]University of Nebraska-Lincoln, [2]DPI Global, Porterville, CA.*

Ninety-six calves (321 ± 8.5 kg) were stratified by BW, and assigned randomly to 12 pens to evaluate the impact of feeding Micro-Aid in diets containing wet distillers grains plus solubles (WDGS) to finishing cattle on performance and N mass balance. Micro-Aid is manufactured from an all-natural plant extract, which contains saponins that have natural detergent and surfactant properties. Steers were fed for 160 d from May to November. Dietary treatments consisted of 35% WDGS, 55% corn, 5% straw, and 5% supplement (CON), with Micro-Aid being added in the treatment supplement at an inclusion of 1g per steer daily (TRT). Nitrogen excretion was determined by the difference between N intake and individual steer N retention. Total N lost was calculated by subtracting manure and runoff N from excreted N. Intake, ADG, and G:F were similar among treatments ($P \geq 0.67$), as well as carcass characteristics. Nitrogen intake, retention, and excretion were also similar ($P \geq 0.73$). There was no difference ($P \geq 0.95$) in the amount of DM and N removed during pen cleaning. N runoff was not different ($P = 0.20$) between treatments at 3.68% of N excretion. The amount of N lost via volatilization was similar among treatments (24.0 kg and 24.5 kg for the CON and Micro-Aid, respectively). Therefore, the percent N loss expressed as a percentage of N excretion was 71.9% for the CON group and 73.8% for the Micro-Aid group. ($P = 0.60$) Treatment did not affect amount of OM removed ($P = 0.64$), with 125 kg for the CON group and 104 kg for cattle fed Micro-Aid. Performance and carcass characteristics were similar between the CON and TRT cattle. Additionally, inclusion of Micro-Aid in the diet fed during the summer has no effect on N and OM removed. However, this contradicts the previous winter experiment in which feeding Micro-Aid led to less N volatilization.

Key words: nitrogen, mass balance, saponins

287 Rumen-protected arginine supplementation alters vascular hemodynamics in forage-fed steers. A. M. Meyer*[1], C. B. Saevre[1], D. V. Dhuyvetter[2], R. E. Musser[3], and J. S. Caton[1], *[1]Center for Nutrition and Pregnancy, Department of Animal Science, North Dakota State University, Fargo, [2]Ridley Block Operations, Mankato, MN, [3]SODA Feed Ingredients LLC, Mankato, MN.*

We hypothesized that Arg supplementation would alter vascular hemodynamics and increase systemic blood flow through its role in nitric oxide synthesis. To test this, 4 steers were used in a 4 × 4 Latin square with the following twice daily treatments: ad libitum grass hay (7.2% CP and 67.6% NDF; CON), hay and 27 mg Arg/kg BW injected intravenously (Arg-INJ), hay with 90 mg rumen-protected Arg/kg BW (Arg-180), and hay with 180 mg rumen-protected Arg/kg BW (Arg-360). Arginine in Arg-180 was estimated to be equal to Arg-INJ. Each period consisted of a 7-d adaptation then 14 d of Arg treatments. Blood flow and hemodynamics of the carotid and caudal arteries were determined using color Doppler ultrasonography on d −1 (baseline), 5, 9, and 14 of Arg treatment. Data were analyzed as repeated measures with treatment, day, and their interaction as fixed effects and steer and period as random effects. As expected, daily serum Arg was greater ($P < 0.001$) in Arg-INJ than all other treatments. Additionally, serum Arg was greater ($P = 0.005$) in Arg-360 than CON, with Arg-180 intermediate. Pulsatility index (PI) and resistance index (RI) percent changes from baseline were affected ($P \leq 0.08$) by treatment in the carotid and caudal arteries. Steers fed Arg-180 had decreased ($P \leq 0.02$) carotid RI and caudal PI compared with CON and Arg-360, indicating reduced vascular resistance and increased tissue blood perfusion. Carotid PI also decreased ($P \leq 0.06$) in Arg-180 compared with CON and Arg-INJ. Furthermore, caudal RI decreased ($P \leq 0.01$) and caudal end diastolic velocity increased ($P \leq 0.06$) in Arg-180 compared with all other treatments. Steers receiving Arg-INJ had decreased ($P < 0.10$) carotid RI compared with CON and decreased ($P = 0.04$) caudal RI compared with Arg-360. There was no effect ($P > 0.19$) of treatment on carotid or caudal flow volume, peak systolic velocity, mean velocity, or cross sectional area. Heart rate, stroke volume, and cardiac output were also unaffected ($P > 0.15$) by treatment. These data suggest that 180 mg rumen-protected Arg/kg BW improved vascular hemodynamics and tissue perfusion without altering serum Arg concentration.

Key words: arginine, blood flow, vascular hemodynamics

288 Effect of supplemental vitamin C on performance and antioxidant capacity of cattle fed varying concentrations of dietary sulfur. D. J. Pogge* and S. L. Hansen, *Iowa State University, Ames, IA, USA.*

Increased dietary sulfur (S) may create oxidative stress which negatively affects performance of feedlot cattle and may contribute to S toxicosis. Therefore, the effect of supplemental rumen-protected vitamin C (Vit C) on antioxidant capacity of cattle consuming high S diets was evaluated in a finishing trial utilizing 120 Angus crossbred steers. Steers were stratified by initial BW (354.9 ± 22.6 kg), and assigned to treatments (4 steers per pen, 5 pens per treatment). Treatments included: 1) low S, corn-based diet, 2) low S + Vit C, 3) medium S, 40% DDGS diet, 4) medium S + Vit C, 5) high S, medium S + 0.3% S from sodium sulfate and 6) high S + Vit C. Diets were formulated to average 0.2, 0.4 and 0.6% S, for low, medium and high S, respectively, and Vit C supplementation was targeted at 10 $g \cdot h^{-1} \cdot d^{-1}$. Rumen hydrogen sulfide concentrations and blood sulfhemoglobin concentrations (n = 5 per treatment) were measured on d 14, 28 and 90. Data were analyzed as repeated measures, and both hydrogen sulfide and sulfhemoglobin concentrations were greater ($P < 0.05$) in steers receiving medium and high S diets compared with steers receiving low S diets. Initial antioxidant status was not different due to treatment (n = 5 per treatment); however, plasma antioxidant capacity measured on d 90 was decreased ($P < 0.01$) in steers receiving medium or high S diets versus low S steers. Increasing dietary S concentrations resulted in a linear decrease ($P < 0.05$) in 12th rib back fat and percent intramuscular fat as determined by ultrasound on d 90. Dry matter intake and ADG for the 112 d period were not affected by Vit C supplementation; however, ADG was negatively affected ($P < 0.05$) by the linear increase of dietary S. In conclusion, medium or high dietary S decreased total antioxidant capacity of steers compared with those fed low S diets, which may contribute to increased susceptibility to S toxicosis when cattle are fed high S diets.

Key words: antioxidant, sulfur, vitamin C

289 Use of MTB-100, provided through a mineral mix, to reduce toxicity when lactating beef cows graze endophyte-infected tall fescue. M. E. Hoar*, D. K. Aaron, D. G. Ely, M. M. Simpson, and A. K. Lunsford, *University of Kentucky, Lexington.*

Sixty, 3 to 5 yr-old, Angus and Angus × Beefmaster cows and their calves were used in a 3-yr study to evaluate response to gradient levels of a nutritional supplement produced from a carbohydrate-based toxin adsorbent (MTB-100 Alltech, Inc., Nicholasville, KY). The supplement was carried in a mineral mix and was available to cows ad libitum. The MTB-100 was mixed with a complete mineral, diluted with white salt, so daily intake was projected to be either 0, 20 or 40 g/cow. The grazing season began on May 8 each yr. From this date until July 10 (Period 1), cows and calves were managed in 9, endophyte-infected (>90%) KY 31 tall fescue pastures (3 pastures/supplement level, re-randomized each yr) stocked with 10 to 16 cow/calf pairs each. On July 10 each yr, 21 pre-designated cow/calf pairs were allotted to individual, 1.6-ha plots of equivalent pasture (7 plots/supplement, re-randomized each yr). Cows continued their respective supplement regimens from this date until calves were weaned on September 13 (Period 2). Cow weight changes in Period 1 were −11.7, −1.9 and −3.2 kg/hd ($P = 0.19$) for 0, 20 and 40 g supplement levels. Although corresponding weight changes in Period 2 showed no significant trend, total cow weight changes from May 8 to September 13 were −7.4, −0.5 and 0.5 kg/hd for 0, 20 and 40 g supplement levels. Cow BCS did not change from May 8 to July 10 (Period 1). Cow BCS on July 10 (5.5, 5.6 and 5.0) decreased to 5.1, 5.4 and 5.0 ($P = 0.03$) for 0, 20 and 40 g treatments (Period 2). Rectal temperatures were not affected by MTB-100^{TM} consumption. Calf weights for Period 1 were 53, 56 and 56 kg/hd (NS) for the 0, 20 and 40 g levels. Calf gains in Period 2 were not different. Overall calf gains from May 8 to September 13 were 109, 112 and 111 kg/hd for 0, 20 and 40 g MTB-100. These results show MTB-100^{TM} consumption, through a mineral mix available ad-libitum, did not increase performance of cows and calves grazing endophyte-infected tall fescue forage.

Key words: adsorbent, cows, fescue

290 In vitro mitigation of rumen hydrogen sulfide. M. Ruiz-Moreno*, E. Seitz, and M. D. Stern, *University of Minnesota, St. Paul.*

Excessive release of rumen hydrogen sulfide (H_2S) has been associated with sulfur-induced polioencephalomalacia. Bismuth subsalicylate (BSS) has been used to decrease H_2S production in humans but its effect on rumen H_2S production is unknown. An in vitro rumen incubation was conducted to assess the effect of 5 levels of BSS on H_2S release and rumen metabolism during 2 consecutive 24-h periods. A diet consisting of 50% corn, 40% dried distillers grains, 9.75% hay and 0.25% mineral premix provided substrate for microbial metabolism. Chemical grade BSS was added to a final concentration of 0 (Control), 0.5, 1, 2 and 4% of DM. Rumen fluid was obtained from a cannulated dairy cow and mixed with McDougall's saliva to a 1:2 ratio. Treatments were assigned in 5 replicates to 120-mL serum bottles containing 50 mL of the inoculum mix and 0.5 g of dietary DM. Bottles were flushed with N_2, crimp sealed and incubated during 24 h at 39.1°C. At the end of incubation, gas volume and H_2S in the headspace of bottles were quantified. Final pH was recorded and incubation fluid was analyzed for NH_3-N and VFA. Data were analyzed as a randomized complete block design using ANOVA with Bonferroni correction. Final pH increased ($P < 0.05$) with 2 and 4% BSS by 0.06 and 0.22 pH units, respectively. No effect ($P > 0.05$) of BSS on NH_3-N concentration was observed. At 4% of DM, BSS decreased ($P < 0.05$) total VFA concentration by 15% and molar proportion of propionic acid by 5.7% while increasing acetic acid by 1.5% and the A:P ratio from 2.4 to 2.6, compared with the control. With 2% BSS, molar proportion of butyric acid was 9% lower than the control ($P < 0.05$). Concentration of branched-chain VFA was 19% higher ($P < 0.05$) with the addition of 0.5% BSS, compared with the control. All levels of BSS increased ($P < 0.05$) valeric acid molar proportion compared with 0% BSS. Compared with the control, gas production decreased ($P < 0.05$) with the addition of 2 and 4% BSS by 12 and 25%, respectively. All concentrations of BSS reduced ($P < 0.05$) H_2S production by 18, 24, 82 and 99% for 0.5, 1, 2 and 4% BSS, respectively. Results indicate that BSS can markedly decrease H_2S production.

Key words: rumen, hydrogen sulfide, bismuth subsalicylate

291 Utilizing crop residues in winter feeding systems for beef cows. A. D. Krause*[1] and H. A. Lardner[1,2], [1]*University of Saskatchewan, Saskatoon, Saskatchewan, Canada,* [2]*Western Beef Development Centre, Humbolt, Saskatchewan, Canada.*

An experiment was conducted to evaluate the effects of winter feeding system on beef cow performance, reproductive efficiency and economics. Winter feeding systems were grazing pea (*Pisum sativum* cv. Performance 40–10) crop residue (PEA) (TDN = 47.7%; CP = 7.3%), grazing oat (Avena sativa cv. Baler) crop residue (OAT) (TDN = 44.9%; CP = 2.3%), and grass-legume hay fed in drylot pens (DL) (TDN = 52.8%; CP = 9.1%). Ninety dry, pregnant Angus cows (629 kg ± 74 kg) stratified by body weight (BW) and days pregnant were allocated to 1 of 3 replicated (n = 3) treatments. Statistical analysis was conducted as a one way ANOVA using the Proc Mixed Model

procedure of SAS. Experimental design for feeding was a completely randomized design. Cows were allocated crop residue in field on a 3-d basis and supplemented oat grain daily at 0.4-0.6% of BW depending on environmental conditions. Dry matter intake (DMI) was measured for each treatment using the herbage weight disappearance method. Cow BW, body condition score (BCS), and rib and rump fat were measured at start and end of trial. Cow BW was corrected for conceptus gain based on calving data. Reproductive performance data collected included calf birth weight, calf birth date, calving span and calving rate. Cow BW was different ($P = 0.0001$) between all grazing systems. Drylot system cows had the greatest positive BW change (66 kg), and cows in the PEA system had the lowest positive BW change (10 kg). Rib and rump fat were also different ($P = 0.002$) between systems. Rib and rump fat changes were greater for the DL cows compared to cows in the PEA wintering system. Estimated DMI averaged over the winter feeding period was 13.1, 7.1 and 6.9 kg for DL, OAT and PEA cows, respectively. Mean calf birth weights for DL, OAT and PEA cows were 40.9, 36.8 and 40.3 kg, respectively. Winter feeding system costs per cow per day were $1.34, $1.07 and $2.78 for PEA, OAT and DL treatments, respectively. Results of this study indicate that it is possible to maintain cow BW during winter months in western Canada while grazing crop residues, which have the potential to reduce winter feeding costs associated with winter cow management.

Key words: pea crop residue, oat crop residue, beef cows

292 Effect of supplementing dried distillers grains to cattle consuming low-quality South Texas forage. M. C. Briggs*[1], K. C. McCuistion[1], R. O. Dittmar III[2], J. E. Zradicka[1], D. Kinkel[1], and T. A. Wickersham[2], *[1]Texas A&M University, Kingsville, Kingsville, [2]Texas A&M University, College Station.*

Protein supplementation is often used in South Texas to improve cow performance on dormant forage. However, little data are available evaluating the use of dried distillers grains (DDG) as a source of supplemental protein. Therefore, we used 13 ruminally fistulated steers in a 13 × 4 incomplete Latin square with 13 treatments and 4 periods. Steers were provided ad libitum access to low-quality (3.6% CP, 72.7% NDF) mixed grass hay. Treatments were arranged in a 3 × 4 factorial plus a positive control, alfalfa. The first factor compared 3 supplemental protein sources: cotton seed meal (CSM; 42.2% CP, 30.0% NDF), DDG (25.2% CP, 32.4% NDF) and DDG plus urea (DDGU; 35.6% CP, 32.4% NDF). The second factor consisted of 4 levels of the 3 supplemental protein sources provided at 0, 52, 104, and 156 mg N/kg of initial BW. Experimental periods were 16 d long with 10 d for adaptation. Forage OM intake (FOMI) increased linearly with DDGU ($P \leq 0.02$; 44.9, 52.4, 52.2, and 56.1 g/kg $BW^{0.75}$, for 0, 52, 104, and 156 mg N/kg BW, respectively) and CSM ($P < 0.01$; 46.9, 49.3, 53.3, and 57.1 g/kg $BW^{0.75}$, for 0, 52, 104, and 156 mg N/kg BW, respectively). However, increasing provision of DDG did not significantly affect FOMI ($P \geq 0.32$). In contrast, there was a linear ($P < 0.01$) increase in total OM intake (TOMI) when DDG was supplemented, with intakes increasing from 45.2 to 51.7, 60.2, and 63.0 g/kg $BW^{0.75}$, for 0, 52, 104, and 156 mg N/kg BW, respectively. Similar linear increases in TOMI were observed for CSM ($P < 0.01$) and DDGU ($P < 0.01$). Ruminal ammonia concentrations increased linearly with CSM ($P < 0.01$) and DDGU ($P < 0.01$) but were not affected by DDG ($P \geq 0.44$) supplementation. Both CSM and DDGU were effective at stimulating TOMI, with a portion of this response attributable to increased FOMI. In contrast, DDG was effective at increasing TOMI, but this was largely driven by the intake of supplement. Supplementation with DDG alone may be most effective when forage quantity is limited and substitution is desirable.

Key words: cattle, dried distillers grains, forage

293 A mechanistic model of enteric methane emissions from ruminants. R. A. Kohn* and S.-W. Kim, *University of Maryland, College Park.*

Most models of microbial metabolism assume kinetic control wherein rates of reactions depend on substrate or enzyme activity, and enzyme activity may in turn be controlled by gene expression. However, such models are frequently unstable and inaccurate. Thermodynamic control occurs when concentrations of metabolites build up relative to concentrations of reactants, such as when there is a high degree of competition for substrate and limited opportunity for removal of products. The second law of thermodynamics explains why certain profiles of volatile fatty acids (VFA) and gases (e.g., CH_4, CO_2 and H_2) occur in the rumen. According to current dogma, methane is produced from CO_2 and $4H_2$ in the rumen, but from degradation of acetate to CO_2 and CH_4 in anaerobic digesters. It was thought that rapid dilution rates wash out the slow-growing acetate-degrading (acetoclastic) organisms from the rumen. However, calculations of ΔG show that the reactions: acetic acid $\longleftrightarrow 2CO_2 + 4H_2$ and $CH_4 + 2H_2O \longleftrightarrow CO_2 + 4H_2$ are near equilibrium on forage-based diets. Thus, rate of acetic acid degradation is limited by thermodynamics and not kinetics. The gases in the rumen under 1 atm pressure ultimately limit degradation of acetic acid. Rumen microbes degraded acetic acid when incubated under partial vacuum or N_2. We are developing an integrated thermodynamic and kinetic model to predict methane emissions from VFA concentrations, which are in turn predicted from VFA production rates and VFA absorption and passage. These rates are in turn predicted from organic matter digestion in the rumen. An explanation for the decrease in ratio of concentration of acetate to propionate follows: [acetic acid] / $\{[CO_2]^2[H_2]^4\} = K_{eq}$ so as acid concentration builds up with high grain diets, H_2 pressure builds up (as observed) to maintain equilibrium. The greater H_2 concentration increases the equilibrium concentrations of VFA, particularly of propionate, thereby decreasing production of CO_2 and H_2 as precursors for methane. The model explains mechanisms of some factors that change methane emissions and suggests ways to decrease enteric methane emissions.

Key words: methane emissions, mathematical model, thermodynamics