Production, Management and the Environment: Environmental Quality

848 Ammonia emissions from a commercial feedyard measured using passive samplers and a box model. N. A. Cole*[1], R. W. Todd[1], D. B. Parker[2], M. Rhoades[3], and A. Mason[1], [1]*USDA-ARS, Conservation & Production Research Lab, Bushland, TX,* [2]*USDA-ARS-MARC, Clay Center, NE,* [3]*West Texas A&M University, Canyon.*

Animal feeding operations are a major source of ammonia gas emitted to the atmosphere. Ammonia emissions can potentially affect air quality and sensitive ecosystems, but because measuring ammonia emissions from open lots is difficult, few studies have investigated ammonia losses from beef cattle feedyards. Our objective was to measure ammonia emissions from a 77-ha, 45,000-head beef cattle feedyard on the southern High Plains. Profiles of ammonia concentration, wind speed, and air temperature were measured downwind (5 d in summer) or in the middle (6 d in winter) of the feedyard. In addition, ammonia concentrations were measured at 7 locations downwind (summer) or in the middle (winter) of the yard using a combination of active and passive samplers. Ammonia flux was estimated using a box model. Samples of rations, fresh feces, pen manure, and compost were obtained for chemical analyses (DM, N, P). Dietary N concentrations averaged 2.14% during the summer and 2.51% during the winter. Hourly ammonia-N flux averaged 365 ± 49 mg/m^2 in the summer and 212 ± 92 mg/m^2 in the winter. Ammonia-N emission rates averaged 5,453 ± 741 kg/d in the summer (63% of N intake), and 3,170 ± 1,383 kg/d in the winter (31% of N intake), with an annualized average of 4,311 ± 1,612 kg/d (47% of N intake). Nitrogen volatilization losses, estimated from the changes in the N:P ratio of rations and dry pen manure, averaged 42% of N intake. The annualized emission factor was 15.4 ± 2.2 kg ammonia-N/head fed. Nitrogen volatilization losses from the compost windrows, estimated from changes in the N:P ratio of manure and compost, averaged 3.4 ± 1.4% of N placed in the windrows during winter and 13.3 ± 1.3% in summer. Ammonia-N volatilization losses from the retention pond, estimated using an empirical model, averaged 5.5 ± 4.4 kg/ha daily or 166 ± 130 kg/d. These values agree well with emissions estimated using an inverse dispersion model and demonstrate that the pen surface is the primary source of feedlot ammonia, and that emissions are greater in summer than winter. This research was partially supported by grant #TS2006–06009 from the USDA-CSREES.

Key words: beef cattle, ammonia, emissions

849 Effects of feeding birdsfoot-trefoil on greenhouse gases emissions from fresh and land incorporated dairy manure. Q. Wang*, R. Franco, Y. Zhao, Y. Pan, and F. Mitloehner, *University of California, Davis, Davis.*

Birdsfoot-trefoil, a legume containing condensed tannins, may improve N utilization efficiency and shift urine N to fecal N. This shift might affect greenhouse gas (GHG) emissions because fecal N versus urine N is less utilizable by denitrifying bacteria that produce GHG from manure. The present study investigated the effects of feeding birdsfoot-trefoil (BFT) on GHG emissions from fresh and land-incorporated dairy manure (LIDM). Eighteen lactating Holstein cows were randomly assigned to 1 of the 2 treatments: 1) alfalfa (ALF) based ration, and 2) BFT based ration. Within each treatment, 9 cows were randomly assigned to 3 groups (n = 3). Animals were fed the respective diets for 8 d and then moved into an environmentally controlled chamber for 12 h to allow for GHG monitoring. Blood samples for blood urea N analysis were collected before cows left the chamber. The fresh manure was left on the chamber floor for 12 h to measure GHG emissions with INNOVA 1412 gas analyzer. CO_2, CH_4 and N_2O emissions from the fresh manure of ALF and BFT fed cows are 5.29, 0.05, 0.01 ppm and 4.71, 0.10, 0.01 ppm, respectively. Then the aged manure was collected and incorporated into loamy soil to simulate LIDM. Flux chambers were connected to the INNOVA 1412 gas analyzer to measure GHG emissions from LIDM over a 10 d period. CO_2 and N_2O emissions from the LIDM of ALF and BFT fed cows are 102.70, 0.02 ppm and 78.15, 0.02 ppm, respectively. Blood urea N was lower in BFT versus ALF fed animals ($P < 0.05$). However, GHG emissions were similar between BFT and ALF fed cow manure. In the present study, BFT did not affect the GHG emissions from dairy manure. A follow-up study, will investigate the effects of BFT on N partitioning over time.

Key words: alfalfa, birdsfoot-trefoil, greenhouse gas

850 Prediction of individual methane emission by dairy cattle from milk mid-infrared spectra. A. Vanlierde*[1], C. Delfosse[1], F. Dehareng[1], E. Froidmont[2], H. Soyeurt[3,4], M. Hammida[1], J.-M. Romnee[1], and P. Dardenne[1], [1]*Walloon Agricultural Research Centre, Quality Department, Gembloux, Belgium,* [2]*Walloon Agricultural Research Centre, Department of Production and Sectors, Gembloux, Belgium,* [3]*University of Liège Gembloux Agro-Bio Tech, Animal Science Unit, Gembloux, Belgium,* [4]*National Fund for Scientific Research, Brussels, Belgium.*

Methane produced by ruminants contributes to global warming. Different experiments were conducted on Holstein cows to predict their individual methane production. The objective was to obtain a wide variation in methane emissions to establish predictive equations. For this, the cows were selected according to their stage and number of lactation and received different types of diet known to promote or not the production of methane during rumen fermentation. Individual methane emission was daily measured by a sulfur hexafluoride tracer during a week. In the same time, a sample of individual milk was analyzed by mid-infrared (MIR) spectrometry. The daily methane data was then related to an average of daily milk spectrum (AMS). Five different calculations were used because of the delay between the generation of fermentation products and their use in the milk components. The methane emissions were compared with AMS at d 0, 0.5, 1, 1.5, and 2. Equations were built with partial last square regression and showed that the AMS at d 1.5 gave the best prediction of the CH4 emission with a cross validation R^2 of 0.79. It indicates that there is more than one day between the formation of feed fermentation products and their “detection” in milk analysis. There is also a close correlation between fatty acid (FA) profile and methane emission at d 1.5. However, results show that applying directly the developed methane equation gives a better prediction than the use of correlation between FA and methane. These observations suggest the feasibility of methane prediction from MIR spectra. Now, it is important to increase the reliability of prediction and make a validation to predict continuously the individual methane emissions in small and large scales and also to identify low methane emitted cows.

Key words: methane, mid–infrared, milk

851 Effects of biotechnology on greenhouse gases, volatile organic compounds, and ammonia from feedlot cattle. K. R. Stackhouse*, M. S. Calvo, S. E. Place, T. L. Armitage, Y. Pan, Y. Zhao, and F. M. Mitloehner, *University of California, Davis.*

The feedlot industry uses biotechnologies such as antibiotics, growth implants, and β_2-adrenergic agonists to improve health and growth performance of cattle. These biotechnologies alter microbes in the rumen and nitrogen retention in the animal, which may lead to changes in greenhouse gas (GHG), volatile organic compound (VOC), and ammonia emissions from feedlots. The present study investigated GHG, VOC, and ammonia emissions from 160 Black Angus steers. Steers were blocked by weight and randomly assigned to 16 pens of 10 animals each. Treatments applied were: (1) control (no biotechnology application, CON), (2) Rumensin and Tylosin (RUM), (3) Rumensin, Tylosin, and Revalor-s (IMP), and (4) Rumensin, Tylosin, Revalor-s, and Zilpaterol hydrochloride (BAA). Cattle were on feed for an average of 107 d and performance and blood urea nitrogen (BUN) measured. Gaseous emissions were measured during the last 10 d of the feeding period when animals were housed in 4 totally enclosed identical cattle pen enclosures. The control was compared with 3 treatment groups using a 4 by 4 Latin square design (n = 4). Nitrous oxide, carbon dioxide, methanol, ethanol, and ammonia were measured using the INNOVA 1412 gas analyzer. Methane was measured using the TEI 55C analyzer. Emissions are reported in g^{-1} kg HCW^{-1} d. All measurements were analyzed using Proc Mixed in SAS. Treatment with IMP and BAA increased ($P < 0.05$) ADG and final BW. BAA vs. other treatments increased HCW ($P < 0.05$) and reduced ($P < 0.05$) methane and ammonia emissions as well as BUN. The present study will provide a better understanding of how antibiotics and growth enhancement application used in feedlot cattle affect atmospheric emissions of GHGs, VOCs, and ammonia per kg of product.

Key words: beef cattle, greenhouse gas, ammonia

852 Life cycle assessment of greenhouse gas emissions from beef production systems in California.
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Beef production is recognized as a source of GHG emissions; however, little information exists on the net emission from production systems. A life cycle assessment (LCA) was conducted using the Integrated Farm System Model (IFSM) to estimate whole-farm GHG emissions from representative beef production systems in California. The IFSM is a process-level farm model that simulates crop production, feed production and use, animal production, and the return of manure nutrients back to the land to predict the environmental impacts and economics of production systems. The carbon footprint of major production systems was determined as the net exchange of all GHG in carbon dioxide (CO_2) equivalent units per unit of HCW produced. The calculation of net emissions determined the relative contributions of the cow-calf, stocker, and feedlot phases of beef production to the overall carbon footprint of the consumable product. The IFSM was used to predict all important sources and sinks of methane, nitrous oxide, and carbon dioxide from primary and secondary sources. Primary emission sources included enteric fermentation, manure, cropland used in feed production, and fuel combustion in handling manure and producing feed. Secondary emissions were those produced during the production of resources used on the farm, which included fuel, electricity, machinery, fertilizer, pesticides, and replacement animals. Simulated beef production systems included the cow-calf, stocker, and feedlot phases for the traditional British beef breeds and calf ranch and feedlot phases for Holstein steers. An evaluation of differing production management strategies produced carbon footprint values ranging from 5.4 to 19.3 kg CO_2 equivalent / kg of HCW produced. Within the British beef production cycle, the cow-calf phase was responsible for approximately 70% of total GHG emissions with 12% from feedlot sources. Holstein steers that entered the beef production system as a by-product of milk production had the lowest carbon footprint because the emissions associated with their mothers were attributed to milk rather than meat production.

Key words: beef cattle, carbon footprint, greenhouse gas

853 Effects of calf hutch flooring on air quality and exposure.
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Respiratory diseases in calves are associated with the exposure of airborne pathogenic microorganisms and dust, as well as gases that can compromise the defense mechanisms of the respiratory system. Calf bedding provided inside hutches may increase the exposure of animals to ammonia, particulate matter (PM), and airborne microorganisms. The present study quantified concentrations of these compounds in calf hutches supplied with or without bedding. In addition, the effectiveness of applying sodium bisulfate (SBS), an acidifier, to calf bedding was tested to determine if a reduction in pH could reduce these air compounds. Holstein bull calves (n = 63) were randomly assigned to one of the 3 treatments at 1 d of age: 1) elevated hutches with conventional wooden slatted floor and no bedding (CON); 2) hutches with dirt floor and bedding provided (BED); 3) hutches with dirt floor and bedding treated with SBS provided (SBED). Ammonia, PM, and airborne bacteria were measured weekly inside calf hutches using an INNOVA 1412 multigas analyzer, cyclone and open-face cassette samplers, and Andersen biological cascade impactors, respectively. Ammonia differed ($P < 0.001$) across treatments, with CON yielding the highest (0.57 ± 0.03 ppm) and SBED the lowest (0.35 ± 0.03 ppm) concentrations. The PM concentrations were similar ($P > 0.05$) across treatments for both fine (diameter ≤ 2.5 μm) and coarse (diameter ≥ 2.5 μm) particles. Bacteria concentrations were lower ($P < 0.0001$) for CON (1,163 ± 696 cfu/m^3) versus BED (3,233 ± 731 cfu/m^3) and SBED (2,705 ± 919 cfu/m^3), which were similar ($P > 0.05$). Overall, the results improve the understanding of air quality inside wooden hutches housing newborn calves. The management of calf bedding may affect certain air compounds known to affect respiratory health.

Key words: ammonia, bacteria, calf

854 Feeding saponins to reduce air emissions from steers.
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A series of experiments (Exp) were conducted to quantify the effect of saponin extracts from *Quillaja saponaria* (Q), *Yucca schidigera* (Y) and *Camellia sinensis* (T) on gaseous emissions from steers. Exp1 compared a control diet (C; corn-corn silage basal diet), Y (0.64% DM) and Q (1.5% DM); 4 replicates per treatment. Exp 2 evaluated the effect of T (0.25% DM) and C. Products inclusion level was established to provide the same saponin concentration across Exp. Exp 3 compared C, Q (1.5% DM), Y (1.5% DM) and T (0.5% DM). Holstein steers (n = 12) at initial BW of 353 ± 18 kg (Exp1), 428 ± 23 kg (Exp 2) and 391 ± 22kg (Exp 3) were housed, individually, in environmental rooms for 22 d per study. Emissions of methane (CH_4), ammonia (NH_3), hydrogen sulfide (H_2S), nitrous oxide (N_2O) and non-methane total hydrocarbons (NMTHC) were monitored in room exhaust air. In Exp 1, DMI (7.54 ± 0.09 kg) and ADG (1.11 ± 0.18 kg) were not affected by diet ($P > 0.05$). DMI was improved in Exp 2 by adding TS into the diet (8.94 kg in TS vs. 8.53 in C; $P < 0.05$), while ADG was not affected by diet. During Exp 3 steers fed the T diet ate less (6.43 kg/d) and gained less (0.39 kg/d) compared with the average DMI (8.69 kg) and ADG (1.37 kg) of the other 3 treatments ($P < 0.05$). Across Exp, saponin inclusion did not alter daily CH_4 emission when reported on a DMI basis (13.25, 11.08 and 12.65 g/kg DMI, for Exp 1, 2, and 3, respectively). Daily NH_3 emission was not affected by diet in Exp 1 (17.3 g/d). Feeding TS in Exp 2 reduced NH_3 emissions per unit of N intake (131.0 vs. 186.5 mg/g N intake; $P < 0.05$). Feeding Q in Exp 3 resulted in greater mass of NH_3 emitted compared with the other treatments (18.9 g/d vs. 14.1 g/d; $P > 0.05$). Average daily H_2S, N_2O and NMTHC emissions were 84.59, 2963.78 and 1436.06 mg, respectively, across all Exp with no diet effects observed within Exp ($P > 0.05$). Results show that 0.5% DM of T in diet reduced CH_4 emission at the expense of DMI and ADG. Inclusion of Q and Y demonstrated the potential to increase NH_3 emissions.

Key words: *Quillaja saponaria*, *Yucca schidigera*, *Camellia sinensis*

855 Supplementary concentrate type affects nitrogen balance in early lactation dairy cows offered grazed pasture. S. J. Whelan*, K. M. Pierce, J. J. Callan, B. Flynn, and F. J. Mulligan, *School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland.*

Nitrogen (N) losses from dairy cow production systems have a detrimental effect on the environment. Dietary strategies to improve N balance in dairy cows may help alleviate these effects. This experiment evaluates the effect of supplementary concentrate type on N balance in early lactation dairy cows offered a perennial ryegrass pasture. A total of 48 were assigned to 1 of 4 dietary treatments in a randomized block design (n = 12). All cows received a perennial ryegrass pasture plus one of the following concentrate types: Hi-Pro (18% CP), Lo-Pro (14% CP), Lo-Pro Meth (14% CP, with added methionine) and Lo-Pro Maize (14% CP). Hi-Pro, Lo-Pro and Lo-Pro Meth contained rolled barley, whereas Lo-Pro Maize contained stone ground maize as the starch source. Concentrates were isoenergetic (1.11UFL/kg DM) and offered at 3kg twice daily. On wk 6 and 10 post calving N balance studies were conducted. Data was analyzed using Proc Mixed of the SAS institute. Feed N intake was greater ($P < 0.05$) for Hi-Pro vs. all other dietary treatments; Lo-Pro, Lo-Pro Meth and Lo-Pro Maize were not different ($P > 0.05$). Feces N recovery (N out ÷ N in) was lower ($P < 0.05$) for Hi-Pro vs. all other dietary treatments; Lo-Pro, Lo-Pro Meth and Lo-Pro Maize were not different ($P > 0.05$). Recovery of N in the urine was greater ($P < 0.05$) for Hi-Pro vs. Lo-Pro Meth and Lo-Pro Maize; Lo-Pro was not different ($P > 0.05$) from other treatments. Recovery of N in the milk was lower ($P < 0.05$) for Hi-Pro vs. Lo-Pro Meth and Lo-Pro Maize; Lo-Pro was lower ($P < 0.05$) vs. Lo-Pro Maize but not Hi-Pro or Lo-Pro Meth. Improved milk N recovery with Lo-Pro Maize and Lo-Pro Meth allows for a reduction in urinary N portion.

Table 1. Effect of supplementary concentrate type on nitrogen (N) balance

Concentrate Type	Hi-Pro	Lo-Pro	Lo-Pro Meth	Lo-Pro Maize	SEM
Feed N (kg·d^{-1})	0.511[a]	0.462[b]	0.456[b]	0.445[b]	0.0160
Proportion of ingested N excreted in feces, urine and milk					
Feces	0.376[b]	0.440[a]	0.432[a]	0.418[a]	0.0107
Urine	0.374[a]	0.320[ab]	0.277[b]	0.291[b]	0.0257
Milk	0.250[c]	0.251[bc]	0.284[ab]	0.298[a]	0.0166

[abc]Rows with different superscripts differ ($P < 0.05$).

Key words: nitrogen balance, grazed grass, concentrate type

856 Development of a user-friendly online system to quantitatively measure metabolic gas fluxes from ruminants. P. Zimmerman*[1], S. Zimmerman[1], S. Utsumi[2], and D. Beede[2], [1]*C-Lock Inc., Rapid City, SD,* [2]*Michigan State University, East Lansing.*

We developed and tested a new internet-interfaced system to quantitatively measure methane, carbon dioxide and other metabolic emissions from individual animals and to track changes in emissions over time. Methane is not only a powerful greenhouse gas, but emissions also represent significant losses of energy and feed efficiency. Changes in fluxes are also sensitive indicators of changes in diet, behavior, and health. The system has been tested in robotic dairies, tie-stalls, and pastures. The system includes the following elements: a headstall unit to restrict and control atmospheric mixing; a radio-frequency identification (RFID) of each animal; a feed or water dispenser so that the animal voluntarily keeps its head in the correct position to obtain quantitative, representative metabolic gas measurements; sensors to detect animal head position; a gas intake manifold with mixing and flow conditioning elements; a fan unit to capture expired and eructated gases along with a sensor to measure air flow-rate through the headstall manifold; a tracer gas sampling system; a controlled tracer gas release to calibrate the capture rate of metabolic gases and to corroborate air flow rates; sensors, including methane, carbon dioxide, water vapor, molecular hydrogen, hydrogen sulfide, and air flow rate; a data acquisition and control system; a remote data link to transmit data to a specified secure location; and, a centralized computer for automated data processing. To date, millions of data points have been collected from many individual animals. For beef cattle on pasture, methane emissions averaged 200 g/animal per d; for a herd of lactating dairy cows average methane emissions were 408 g/animal per d over a 7-mo period. A 2-fold difference in methane emissions between high and low emitting animals also was measured. Changes in feeding patterns and health conditions also were reflected in metabolic gas fluxes. For example, carbon dioxide emissions increased significantly with little change in methane fluxes when dairy cattle were moved to a fresh pasture. The system is user-friendly and relatively easy to maintain and operate.

Key words: methane, ruminant, measurement

857 Effects of oxygenated drinking water on gaseous emissions, rumen microorganisms and milk production in dairy cattle. C. J. Neumeier*[1], J. A. McGarvey[2], Y. Pan[1], Y. Zhao[1], and F. M. Mitloehner[1], [1]*Department of Animal Science, University of California-Davis, Davis,* [2]*United States Department of Agriculture, Agricultural Research Service, Albany, CA.*

Dairy cattle production systems contribute to greenhouse gas emissions, predominantly in the form of methane. Enteric methane is formed by methanogenic archaea (methanogens) that require anaerobic conditions to thrive. A water treatment system (Oxion, Hugoton, KS) increases the dissolved oxygen concentration in drinking water. We hypothesize that by increasing the dissolved oxygen concentration of the rumen through intake of oxygenated drinking water, one creates an environment detrimental to the proliferation of methanogens. The present study evaluated carbonaceous and nitrogenous gaseous emissions in addition to performance parameters. A total of 36 lactating Holstein dairy cows were used in a completely randomized design. The cows were assigned to 2 treatment groups: control water and oxygenated drinking water (CON and OXI, respectively). The cows were housed in 3 groups of 6 animals within each treatment (n = 3). Dry matter intake (DMI), water intake and milk yield were recorded daily. Rumen fluid samples were extracted via an orogastric tube and quantified for bacteria, methanogens and protozoa. Cows were placed inside an environmental chamber to measure carbon dioxide, nitrous oxide and ammonia using the Innova 1412 photoacoustic field gas monitor (California Analytical Instruments, Orange, CA) and methane using the TEI 55C direct methane analyzer (Thermo Environmental Instruments, Franklin, MA). All measurements were analyzed using Proc Mixed in SAS. The DMI, water intake and energy corrected milk yield were similar but OXI vs. CON treated cattle showed decreased milk yield ($P < 0.01$). Bacteria, methanogen and protozoa quantification yielded no significant differences. While methane production was similar ammonia emission increased for OXI vs. CON treated cattle ($P < 0.05$). Introduction of excess oxygen to the rumen via drinking water did not produce the anticipated effect on methane reduction but instead seems to cause changes in nitrogen cycling of the animal which deserves further investigation.

Key words: greenhouse gas, methane, water treatment