Ruminant Nutrition: Connecting Rumen Microbiology to Ruminant Nutrition: Are We There Yet?

212 Ruminal nitrogen metabolism: The current microbiological outlook. M. Morrison* and Z. Yu, *The Ohio State University*, *Columbus*.

Historically, the microbiological outlook of ruminal nitrogen metabolism has been focused on the degradative, assimilatory and metabolic fate of nitrogenous compounds. Select bacterial species or "mixed rumen contents" have been used in most of these studies. Sometimes, cultivation-dependent, and more recently, cultivation-independent approaches have been employed to enumerate and observe shifts in microbe numbers. Such studies have allowed us to better understand how substrate preferences and availability affect rumen bacterial growth efficiency and yield, as well as some of the microbial interactions underpinning ruminal proteolysis. However, the variability implicit within the dietary models used by nutritionists for ration formulation suggest we still have much to understand about rumen microbiology and its direct role in affecting protein (amino acid) availability for the host animal. Additionally, there has been scant attention paid to understanding how peptides, amino acids, and other nitrogenous compounds might influence rumen microbial physiology and (or) metabolism; for example as effector molecules coordinating diverse functions such as quorum sensing and the conjugative transfer of genetic material. In other words, how might the intermediates and (or) products of ruminal nitrogen transactions elicit changes in microbial "behavior", resulting in quantifiable alterations of rumen metabolism and nutrient utilization? Microbial (meta)genomics provides the opportunity to examine the rumen microbiome in a more holistic and mechanistic way, and to obtain new insights into gene expression, microbial action and rumen function. We will present several examples of the advances that are emerging from the (meta)genomic analysis of ruminal microbes, within the contextual bases outlined above.

Key Words: Rumen microbiology, Genomics, Nitrogen metabolism

213 Ruminal nitrogen metabolism: The current nutritional outlook. J. L. Firkins*, *The Ohio State University*, *Columbus*.

Historically, research evaluating ruminal nitrogen transactions has primarily focused on aspects concerning the degradative, assimilatory and metabolic fates of nitrogenous compounds. The microbiological aspects of these processes have been integrated into nutritional goals of improving the efficiency of microbial protein synthesis, maximizing amino acid supply to the host animal, and (or) minimizing the loss of nitrogenous compounds in animal waste. As described in the companion paper by Morrison and Yu, microbiological techniques have advanced from phenotypic descriptions of pure and mixed cultures to metagenomic comparisons of population structure in vivo. Correspondingly, although major shifts in microbial populations have been associated with large in vivo treatment differences, more narrow treatment differences have demonstrated shifts in microbial populations that are only relatively comparable to differences among animals fed the same diets, indicating considerable variability in microbial populations occupying similar niches. As nutritionists move toward more sophisticated dietary modeling approaches based on some overall average animal response, we must better account for the variability in model predictions for feeding groups of animals to decrease current reliance on dietary safety factors and anecdotal animal assessment strategies to prevent ruminal acidosis or shortages of rumen degraded protein. Dietary factors influencing ruminal degradative capacity and outflow of microbial protein include the types and numbers of protozoa, the availability of specific nitrogenous and carbohydrate fractions, rumination activity, stratification and location in the rumen, and time after feeding. Besides reviewing such individual processes, the overall aim of this presentation will be to explore how dietary changes influence microbial ecology in the rumen ecosystem as assessed by current and future techniques, thus improving the predictability of microbial end-products and their impact on ruminant nutrition.

Key Words: Ruminant nitrogen metabolism, Microbial ecology, Microbial protein synthesis

214 Ruminal acidosis in beef cattle: The current microbiological outlook. T. G. Nagaraja* and E. C. Titgemeyer, *Kansas State University*, *Manhattan*.

Ruminal acidosis continues to be a common and economically significant ruminal digestive disorder in beef cattle. Ruminal acidosis or increased accumulation of organic acids in the rumen reflects imbalance between microbial production, microbial utilization and ruminal absorption of organic acids The severity of acidosis, generally related to the amount, frequency and duration of grain feeding, varies from acute, typically due to lactic acid accumulation, to subacute acidosis due to accumulation of VFA in the rumen. Ruminal microbial changes associated with acidosis are reflective of increased availability of fermentable substrates and subsequent accumulation of organic acids. Microbial changes in the rumen associated with acute acidosis have been well documented. The changes include increases in lactic acid-producing bacteria, primarily acid-tolerant amylolytic bacteria, and a general decrease in ciliated protozoa and gram negative bacteria, particularly lactic acid-utilizing bacteria. Other microbial factors, such as endotoxin and histamine, are suspected to contribute to the systemic effects of acidosis. Microbial changes in subacute acidosis resemble those observed during adaptation to grain feeding, in that there is a general increase in total number of bacteria, including lactate-utilizing bacteria. The decrease in ciliated protozoal population is a common feature of both forms of acidosis and may be a good microbial indicator of an acidotic condition in the rumen. Ciliated protozoa in the rumen impart a stabilizing effect on the fermentation because of their ability to influence ruminal starch and lactic acid fermentations. However, protozoal populations in the rumen of grain-fed cattle, even after reaching full feed, fluctuate considerably, and not much is known about factors responsible for their volatility. Besides prudent management practices, initial approaches to control acidosis were generally aimed to inhibit or slow down lactic acid-production, but relatively recent methods are also aimed at enhancing ruminal lactate utilization.

Key Words: Rumen, Acidosis, Microorganisms

215 Ruminal acidosis in beef cattle: The current nutritional outlook. E. C. Titgemeyer* and T. G. Nagaraja, *Kansas State University*, *Manhattan*.

Ruminal acidosis in beef cattle can lead to marked reductions in cattle performance. Numerous models have been developed to assess the effects of variation in feed intake, of dietary roughage amount and source, of dietary grain amount and processing, of step-up regimen, and of dietary addition of fibrous byproducts, antibiotics, probiotics,

and direct-fed microbials. These models typically address ruminal fermentation, and they yield useful results that, unfortunately, often differ from those observed for growth performance. Models have been developed to study both the adaptation of cattle to grain-based diets as well as the effects of management considerations on acidosis in cattle previously adapted to grain-based diets. Although these models have provided valuable information related to ruminal acidosis, many of the models have been inadequate for detecting responses to treatment due to inadequate replication (required to overcome the variable responses being studied), low feed intakes by the experimental cattle (which can limit the expression of acidosis), and the feeding of cattle individually (which reduces experimental variation but limits extrapolation of the data to industry conditions). Treatment responses to a wide range of management and nutritional modulations are often explained on the basis of acidosis prevention (or stimulation), whether or not direct evidence of acidosis is available. Optimal model systems for assessing impacts of various management and nutritional strategies on ruminal acidosis will require technologies that allow feed intake patterns, ruminal conditions, and animal health and performance to be measured simultaneously in a large number of cattle managed under conditions similar to commercial feedyards. Data generated under these conditions could provide valuable insight into the true extent to which acidosis impacts cattle performance.

Key Words: Acidosis, Cattle, Rumen

Ruminant Nutrition: Non-fibrous Carbohydrate & By-Product Feedstuffs

216 Influence of endosperm vitreousness and kernel moisture at harvest on site and extent of digestion of high moisture corn by steers. J. Szasz*[1], C. Hunt[1], P. Szasz[1], R. Weber[2], F. Owens[2], and W. Kezar[2], [1]*University of Idaho*, *Moscow*, [2]*Pioneer Hi-Bred International*, *Johnston, IA*.

Six ruminally and duodenally cannulated steers (mean BW 450 kg) were used in a 6 x 6 Latin square to evaluate the impact of kernel vitreousness and moisture on intake and digestibility of high moisture corn. Arranged in a 2 x 3 factorial, diets included a floury (**FLO**) and a vitreous (**VIT**) endosperm hybrid harvested at **DRY**, **MID**, and **WET** kernel moistures (28.1, 31.2, and 35.7%). High moisture corn was dry-rolled and allowed to ensile for at least 45 d. Diet DM consisted of 88% high moisture corn, 6% chopped alfalfa hay, 2.0% corn gluten meal, 0.75% urea, and 3.0% supplement. Geometric mean diameter was less ($P = 0.06$) for VIT than FLO and increased ($P < 0.05$) linearly with kernel moisture content. Surface area was greater ($P < 0.05$) for VIT versus FLO particles. In situ rapidly degraded starch (*a* fraction) and effective starch degradability (assuming 5%/h fractional passage rate) increased linearly ($P < 0.01$) with kernel moisture. An interaction ($P < 0.05$) was observed between kernel vitreousness and moisture for in situ rapidly degraded starch and effective starch degradability, both being greater ($P < 0.05$) for VIT-DRY than FLO-DRY. Intake and ruminal disappearance of DM, OM, and starch were not influenced by vitreousness or moisture. Ruminal starch digestion, averaging 90.9%, was not impacted by dietary treatment. Digestion of starch entering the small intestine, averaging 91.0%, was greater ($P < 0.05$) for VIT than FLO corn. Averaged across moisture levels, total tract starch digestibility was greater ($P < 0.003$) for VIT than FLO. Compared with FLO kernels, VIT kernels were more brittle and shattered more readily when rolled, particularly when DRY. The increased surface area of smaller particles may be responsible for the improved starch utilization. For processed high moisture corn, total tract starch digestibility was greater for the vitreous than the floury endosperm corn.

Key Words: Starch, Processing, Particle size

217 Influence of endosperm vitreousness, moisture at harvest, and microbial inoculant on chemical composition, available starch and ruminal dry matter disappearance of ensiled high moisture corn. J. Szasz*[1], C. Hunt[1], P. Szasz[1], R. Weber[2], F. Owens[2], and W. Kezar[2], [1]*University of Idaho*, *Moscow*, [2]*Pioneer Hi-Bred International*, *Johnston, IA*.

Samples from two corn hybrids, one floury (**FLO**) and one vitreous (**VIT**) endosperm type, were harvested at **DRY**, **MID**, and **WET** kernel moistures (28.1, 31.2, and 35.7 percent moisture, respectively). Samples of rolled high moisture corn from each endosperm by kernel moisture subclass were ensiled in triplicate, with or without a bacterial inoculant (Pioneer ® brand 1189), in polyethylene packets which were then vacuum packed, heat sealed, and stored for a minimum of 210 days. Compared to FLO, fermented VIT tended ($P = 0.10$) to have a lower pH but greater available (enzyme digested) starch, CP, NDF, and ash. Within DRY, protein solubility was greater ($P < 0.05$) for VIT than FLO. Ash content and 24-h in situ DM disappearance increased linearly ($P < 0.05$) with kernel moisture. Microbial inoculation tended ($P < 0.10$) to reduce pH, ash content, and available starch. Within FLO, microbial inoculant reduced ($P < 0.05$) concentration of CP. Microbial inoculant reduced ($P < 0.05$) ammonia N concentration for FLO-DRY, FLO-MID, and VIT-MID compared to non-inoculated high moisture corn. Microbial inoculant increased ($P < 0.05$) 24-h in situ DM disappearance for VIT corn harvested and ensiled DRY. For inoculated DRY corn, 24-h in situ DM disappearance was greater ($P < 0.05$) for VIT than FLO. In a companion study, VIT had smaller particle size than FLO, particularly for DRY treatments. Accordingly, the greater starch availability and soluble CP for VIT compared to FLO may have been due partly to smaller particle size and greater surface area. The beneficial response from the microbial inoculant for DRY-VIT also may be a result of application of the inoculant to smaller particle size corn characteristic of DRY-VIT compared with DRY-FLO.

Key Words: Processing, Particle size, In situ

218 Effects of feeding steam-rolled corn in lieu of dry-rolled corn on the odor of finishing beef steer manure. S. L. Archibeque*[1], D. N. Miller[2], D. B. Parker[3], H. C. Freetly[1], and C. L. Ferrell[1], [1]*USDA, ARS, U.S. Meat Animal Research Center*, *Clay Center, NE*, [2]*USDA, ARS, Soil and Water Conservation Research Unit*, *Lincoln, NE*, [3]*West Texas A&M University*, *Canyon*.

Fecal starch is the major source of odorous compounds produced in the manure of steers fed typical finishing diets. We hypothesized that feeding steam-rolled corn (**SR**) in lieu of dry-rolled corn (**DR**) in finishing diets would increase starch digestibility and thus reduce odor production from manure. Eight steers (318 ±15 kg) were used in a nutrient balance trial with a crossover design and fed either a DR- or SR-based finishing diet. Feces collected during the first day of each balance trial were analyzed for volatile organic compound emission and olfactometry by a trained sensory panel. There was no difference ($P = 0.96$) in starch intake between steers fed DR (4,293 g/d) or SR (4,283 g/d) diets, but fecal starch of steers fed SR (253 g/d) was lower ($P < 0.01$) than that of steers fed DR (490 g/d). Although N intake was