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NDS Dynamics

Welcome to the NDS Dynamics newsletter!

Welcome to the last issue for 2020!
In this issue, professor M.Van Amburgh illustrates how to optimize nitrogen utilization by modelling and integrating metabolizable energy and protein supply and requirements in dairy cattle.
Furthermore, professor T. De Vries discuss how to best manage calves to optimize lifetime eating behavior.
This time, the NDS Dynamics newsletter will not have the column "NDS UPDATES" which will be back next year again.
The teams at RUM&N and at NDS North America take the opportunity to wish all their readers a happy and safe festive season, and end of this "unusual" (to say the least) year, while keeping working to strive towards an even better service for next year.
Please continue to follow us on our channels and contact us for any enquire you may have.

The Editor
Ermanno Melli

Modeling and Integrating Metabolizable Energy and Protein Supply and Requirements in Dry and Lactating Dairy Cattle to Optimize Nitrogen Utilization

By M. Van Amburgh et al.
Cornell University

Improving the prediction of supply and use of metabolizable energy (ME) and protein (MP) is dependent on several factors that can be measured routinely or predicted with reasonable precision. The prediction of ME is dependent on factors such as total feed intake, the chemical composition of the feed consumed, and ruminal and post-ruminal digestibility. The prediction of MP is dependent on the same factors, although MP is more complex as it is highly dependent on the quantity, profile and digestibility of amino acids that escapes the rumen, whereas substrates for ME can be absorbed anywhere along the GIT, recognizing how those substrates are partitioned are different as they are absorbed farther down the GIT. Feed protein is one of the most expensive macronutrients in dairy cattle rations, and overfeeding degradable protein relative to supply results in excessive N losses to the environment (Huhtanen and Hristov, 2009). Efficient use of feed N can be achieved by first meeting the requirements of the rumen microbial population, followed by balancing diets to meet the amino acid requirements of the cow. To decrease competition for quality protein that could otherwise be fed to humans, dairy cattle can be fed byproducts of human food production, thereby converting waste product streams into highly valuable milk protein.

To frame the discussion the Cornell Net Carbohydrate and Protein System (CNCPS) will be utilized to describe the modeling aspects related to ME, MP and amino acid supply and requirements (Tylutki et al., 2008; Higgs, 2014; Van Amburgh et al., 2015). There are at least five major steps necessary to improve the prediction of MP and AA supply and requirements in a lactating and dry cow. Most of this discussion will involve basic structural changes in thinking relative to predictions and requirements. Those five areas are the use, characterization and application of crude protein, recycled urea and endogenous protein, intestinal digestibility and determining first limiting nutrients through integration of protein requirements with energy supply.

The proportion of urea returned to the GIT relative to urea production is remarkably uniform among experiments when animals are fed diets at, or in moderate excess of MP requirements (Lapierre et al., 2004, Ouellet et al., 2004, Recktenwald, 2007, Valkeners et al., 2007). However, recycling increases when N supply is limited (Reynolds and Kristensen, 2008, Valkeners et al., 2007) and decreases when N supply is greatly in excess (Lapierre et al., 2004, Reynolds and Kristensen, 2008). To estimate the proportion of urea returned to the GIT in v7 of CNCPS, the equations presented in Recktenwald et al. (2014) and Reynolds and Kristensen (2008) were used in combination. Recktenwald et al. (2014) showed a linear relationship between urea production and urea recycling in high producing cows fed diets ranging from 15% - 17% CP, while, Reynolds and Kristensen (2008) showed an increase in the proportion of urea recycled at very low N intakes.

Therefore, using equations from Recketenwald et al. and Reynolds and Kristensen in combination allowed for a wider range in dietary conditions to be represented. Recycled urea is distributed to either the rumen, large intestine or small intestine and continues to cycle through the system at steady state. Overall, between 50 and 70% of intake N is converted to urea N and approximately 50% of the urea production is recycled into the GIT. The total pool size of N in the animal dictates how much of the hepatic urea production is captured in the rumen or excreted in the urine. As N intake increases, the probability of recycled urea N being captured by the microbes is reduced; thus, the objective during formulation is to find the balance between the ruminal requirements for ammonia N, N intake and the capacity for N recycling to ensure the optimum efficiency of use. The endogenous nitrogen (EN) secretions occur at various places along the gastrointestinal tract (GIT). Important sources include saliva, gastric juices, bile, pancreatic secretions, sloughed epithelial cells and mucin (Tamminga et al., 1995). Gross EN to the forestomach and intestines were estimated in the CNCPS according to Ouellet et al. (2002) and Ouellet et al. (2010), which were subsequently partitioned into individual components using estimates reported in Egan et al. (1984). Endogenous contributions are reasonably consistent among diets when expressed relative to DMI or OMI (Marini et al., 2008; Ouellet et al., 2010; Ouellet et al., 2002; Tamminga et al., 1995). Thus, the model expresses each component as g EN per kg DMI.

An in vitro assay was developed by Ross et al., (2013) that predicts intestinal N indigestibility in cattle using a multi-step approach. A study was conducted by formulating two different diets in high producing cattle using two different blood meals with different predicted intestinal protein indigestibility to test the accuracy and precision of both the assay and our ability to apply those values in the CNCPS for diet formulation.

The current intestinal digestibility of the NDIN fraction for all feeds is 80% and it appears that the assay of Ross et al. (2013) captures that portion of the indigestible protein, therefore by difference; the remaining fractions should be set at 100% digestibility. Thus, with continued testing and implementation of the uN assay for all feeds, the NDIN fraction ID will be set to 100% because it appears that in NDF containing feeds, the uN assay spans both the ADIN and NDIN fractions.

In summary, the uN assay appears to provide protein indigestibility predictions that are consistent with cattle responses and serves as a platform for modifying the approach to predict protein digestibility within the CNCPS and will improve the model's ability to identify the most limiting nutrient. The data also demonstrate that we are ready to move beyond the detergent system of fractionation for protein, to a system that fractionates proteins based on solubility and indigestibility.

The optimum supply of EAA in v7 was estimated similarly to Doepel et al. (2004) using a dataset of studies that infused AA into the abomasum, duodenum, or intravenously and fitted a logistic curve (Higgs, 2014). The optimum supply of each EAA was defined as the point in which a logistic curve was approaching plateau most rapidly (Lysine example; Figure 2). This point is similar to the break-point in the segmented linear model used in the NRC (2001). The impact of energy supply on the utilization of AA was also investigated by regressing the ratio of AAR and AAS against AA supply relative to total ME. Interestingly, the optimum supply of Met and Lys estimated using this approach was 15.1% and 5.7% of EAA, respectively, which is similar to results found in other studies that used different approaches (Rulquin et al., 1993; Schwab, 1996; Schwab et al., 1992).

However, under these circumstances, no relationship was observed between the 'efficiency' of AA use when AA supply was expressed relative to MP supply but a strong relationship was observed when AA were expressed relative to ME supply which is in agreement the findings of Van Straalen et al. (1994). These data suggest when balancing rations it might be more appropriate to consider AA supply relative to ME which is the approach used in swine (NRC, 2012). Establishing requirements for monogastrics is less complicated than in ruminants as the true AA supply is more easily determined (Lapierre et al., 2006). To extend the comparison of non-ruminant to ruminant, the predicted Lys requirement for a lactating sow in the NRC (2012) model is 2.72 g Lys/Mcal ME which is similar to the 3.03 g Lys/Mcal ME calculated in this study for dairy cows. Likewise, the recommended ratios for each EAA and Lys are similar in the dairy cow and sow with the exception of Met and His. These data suggest, as improvements are made to the predictions of true AA supply in dairy cows, consideration of the approach used to balance AA in other species where AA supply is more easily determined could provide opportunities to improve productivity and the efficiency of nutrient use.

To better describe AA supply and requirements and develop approaches to formulate closer to meet the requirements, several steps have been taken to improve the predictions. These approaches provide solutions to offset bias in calculations, improve chemistry to provide information about improved recoveries and digestibilities and provide new insights into how to evaluate AA requirements on an energy allowable basis consistent with monogastric species. It is anticipated that actualizing all of these approaches will allow for lower N feeding and more efficient diets that result in lower cost and less environmental impact of dairy cattle.

NDS Dynamics

Managing dairy calves to optimize lifetime eating behavior

By T. De Vries
University of Guelph

Despite many advances in our knowledge of calf management, the dairy industry continues to be challenged with finding ways to raise replacement dairy heifer calves in such a manner that not only optimizes immediate health, growth, and efficiency, but also is best for their long-term health, production, and welfare. Calf eating behavior is known to not only have immediate consequences on nutrient intake and growth, but there is evidence to suggest that eating patterns are learned and develop early in the life, and persistence of said patterns may occur and have long-term implications.

Intensified milk feeding programs are known to have marked impacts on performance of the calf early in life, including improved rate of weight gain, structural growth, and efficiency of feed conversion (Diaz et al., 2001; Khan et al., 2007). Long-term benefits of greater growth early in life include reduced age at first calving (Raeth-Knight et al., 2009; Davis Rincker et al., 2011) and improvements in milk production (Soberon et al. (2012). Milk allowance may also greatly influence the feeding behavior patterns of the calf. Intensified feeding systems, especially those that provide ad libitum access to milk or milk replacer, allow calves to exhibit a diurnal pattern of milk intake (Miller-Cushon et al., 2013). Calves provided milk ad libitum have peaks of feeding activity at sunrise and sunset, and consume milk in 8 to 10 meals/day (Appleby, 2001; Miller-Cushon et al., 2013). This type of feeding pattern also may influence solid feed consumption, as those calves in the Miller-Cushon et al. (2013) study that had continuous access to milk consumed their solid feed, at a slower rate, in smaller meals, with longer pauses while eating, with a lesser response to feed delivery – all of which are healthy feeding patterns if carried over time.

Solid feed provision is also not only important for immediate growth, but also long-term behavioral development. Early intake of concentrate is critical for rumen development, as rumen papillae development occurs in response to butyrate produced through fermentation of carbohydrates. Provision of forage has long been discouraged, however, there is evidence to suggest that forage provision does not need to reduce concentrate intake, but rather may improve solid feed consumption before and after weaning (Khan et al., 2011; 2012; Terré et al. 2015), as well as improve the rumen environment, papillae health, and promote greater rumen VFA absorption (Beharka et al. ,1998; Khan et al., 2011; Beiranvand et al., 2014; Terré et al. 2015). The positive effects of forage intake on nutrient digestibility are reduced when hay is finely ground, suggesting that benefits of forage are, in part, due to its physical effectiveness (Montoro et al., 2013). In that work it was also demonstrated that provision of physically-effective forage, as opposed to ground forage, reduced the degree to which calves carried over feed sorting behavior post-weaning.

Post-weaning feeding management may also influence the development of feeding patterns. At this time, concentrate is provided in different ways, typically separate from the roughage, on top of the roughage ('top dressing'), or mixed in with the roughage. Feeding growing dairy heifers concentrate top-dressed on forage results in the rapid consumption of the concentrate portion of their ration in very few, large meals prior to consuming the forage (DeVries and von Keyserlingk, 2009; Greter et al., 2010a). Alternatively, providing heifers a TMR from a young age allows them to distribute their feeding activity more evenly throughout the day and compete less for feed than heifers fed a top-dressed ration. In research by Greter et al. (2010b) these behavioral patterns persisted even when there was a ration change to an unfamiliar TMR, suggesting that the animals had not only learned these behavioral patterns, but that these patterns became habitual and may be difficult to extinguish over time.

In addition to feeds and feeding methods, housing management may also play a role in behavioral development. Group housing of calves allows for the social facilitation of feeding behavior, resulting in calves beginning to consume solid feed earlier in life, particularly around weaning (De Paula Vieira et al. 2010; Miller-Cushon and DeVries, 2016). This may be in part due to improved cognitive development (Gaillard et al., 2014; Meagher et al, 2015). Calves housed with social contact gain weight more consistently through weaning (Chua et al., 2002; Miller-Cushon and DeVries, 2016). Thus, social contact may contribute to a more successful weaning transition of calves. Further, Miller-Cushon and DeVries (2016) demonstrated that social housing for calves early in life may have positive impacts meal patterning, which persist post-weaning, and that early social contact may increase the longer-term preference for social feeding.

Controlling competition is a key factor for social housing of dairy calves. Competition may be reduced when milk allowance and number of meals are increased (De Paula Vieira et al., 2008; Herskin et al., 2010), and when calf age and size range in the pen is minimized (Færevik et al., 2010).

The number of available feeding places (for milk and/or solid feed) also impact competition. Minimal competition for access to artificial teats has been shown to reduce milk intake in the early weeks of life for calves fed ad libitum (Miller-Cushon et al., 2014).

Further, calves chose to stand and feed at the same time, even when provided a single feeding space (Miller-Cushon et al., 2014), suggesting that calves may be motivated to feed in synchrony rather than adopting different feeding schedules. In that work, exposure to a competitive feeding environment also had longer-term impacts on feeding and social behavior. Compared to calves reared in a non-competitive feeding environment, calves reared with restricted teat access were found to persistently displace each other more frequently and consume their feed more quickly after weaning, despite having unrestricted access to feed buckets during the post-weaning stage (Miller-Cushon et al., 2014).

Overall, researchers have demonstrated that feeding behavior of dairy calves may have immediate and long-term impacts. To ensure good growth and, potentially, a lifetime

of healthy eating patterns in calves it is critical that sufficient milk is provided, calves eat quality starter, but also have access to physically-effective forage, calves are group housed where possible, and that they are limited in their competition for feed access.

Send us your comments on this topic! Emiliano Raffrenato is at emiliano.raffrenato@rumen.it; Giulia Esposito is at giulia.esposito@rumen.it; Dave Weber is at rumendvm@gmail.com

Note that the features and utilities developed by the NDS team are not components of the underlying CNCPS model. None of the original CNCPS structures or equations have been changed in the NDS platform. NDS does provide sub-models and utilities to provide enhanced predictions based on the original CNCPS model. ***Questions about the use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.***