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Practical Amino Acid Balancing and Energy Status

Dr. Mike Van Amburgh, Dept. of Animal Science, Cornell University

Answers to Questions Asked, Courtesy of:

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Q: Which formula do you use to estimate the energy corrected milk?

Mike: Tyrell and Reid, 1965 adjusted for true protein: 0.327 * milk lbs. + 12.95 * fat lbs. + 7.65 * protein lbs.

Q: How do you predict the microbial protein production in dairy cows to balance for MP amino acids?

Mike: We use CNCPS. Within the latest version, we have two protozoa pools and two bacterial pools to predict microbial growth. It is a sophisticated model. I can share aspects of the submodel, if you are interested.

Q: Do you have available results from experiments in amino acid balancing for sheep?

Brian: Since 2018, Adisseo has conducted several experiments with highly productive lactating ewes and goats (Lacaune and Saanen/Alpine) in leading public research centers (INRA, AgroParisTech and University of Barcelona).

Our results have confirmed specific amino acid limitations also applies to small ruminants. Indeed, our results suggest that small ruminant diets should be balanced for metabolizable methionine at a rate of 2.5% of MP for animals in mid-lactation and other AA should be not co-limiting.

Q: Do you place emphasis on MUNs when balancing on MP?

Mike: No, I do not place emphasis on MUNs when balancing for MP, but I do pay attention to our predictions of rumen ammonia balance. I don't believe MUN values are well calibrated once they drop below about 10 mg/dL, so unless I see individual cows, bulk tank data are irrelevant to any formulation scenario. If I have a PUN, then I want to be sure that no cow drops below 6 mg/dL on PUN as the urea recycling will not be high enough to keep the rumen N balance positive.

Q: Aiming at milkN/urineN = 1 means no extra N for BWG or "other needs." Does this ratio need to change according to the stage of the lactation?

Mike: When we calculate this within the model, we aggregate all of the productive N and not just milk N, so we account for maintenance, growth, pregnancy and lactation N requirements and then compare that to urinary N. It is still possible to be 1:1 or 1.2:1 and meet all the amino acid requirements of the cow while considering all productive N. And yes, stage of lactation can play a role in that calculation. Early lactation cattle are difficult to formulate for ratios greater than 1:1. And this is only for lactating cattle. It's almost impossible to do it for dry cows and quite easy for later lactation cattle. The key is to not overfeed the rumen N, but ensure the balance is positive throughout the day.

Q: Was methionine added to the blood meal quality study?

Brian: Yes. **Smartamine® M** was added, which ensured methionine would not be limiting in the diets and so the different contributions in metabolizable lysine between the two qualities of blood could be demonstrated through responses in Energy Corrected Milk.

Q: Is the 1.2% BW of aNDFom total aNDFom? If so, do you have a target for aNDFom from forages as a %BW?

Mike: Yes, that is total aNDFom, so for forages, we would like to have that as high as possible within digestibility and inventory constraints. Ideally, it would be good to be at 80% of that number with forages, but around the world that would be tough. Ireland and NZ would be easy, areas with cooler season grasses would be easier. Drier climates make it more difficult many times just because of inventory. These numbers were developed by Mertens over the last 40 years, but we don't apply them correctly. Knowing the digestibility of the forages and non-forage feeds is important in understanding how to make the best use of them. And we don't weigh cows, so it is ambiguous.

Q: On the Met/Urea trial, the starch is over 30%. How come?

Mike: When the diet protein levels drop and the forage levels increase, something has to take the space in the diet. In our case, it has been starch. It doesn't have to be that way, but we are also testing other aspects of our model and modeling effort. Ensuring adequate-to-high microbial growth is important in all these studies. However, what you find when formulating diets at 14% to 15% CP for cows averaging 42 to 48 kg milk per day is to keep the ME high enough and maintain lower N intakes. It is difficult to do without more starch if your forage digestibility is not high enough to push the limits of aNDFom intake.

Q: In the work of A. LaPierre, the changes in 1 SD (plus or minus) were quite different in absolute grams. The increase were many more grams than the decrease. It did not seem that you applied exactly 1 SD change. Why?

Mike: The data are not normally distributed, especially when you look among amino acids, so we have to take the data as they are and make the calculations to fit the data. And for each amino acid, the upper and lower bounds do have different ranges as you point out. It is simply the form of the data that leads us to those ranges. It all comes back to the requirement for individual amino acids. When you have a high requirement for a particular amino acid, the range is larger and the distributions tend to be skewed to the high side, and the opposite for AA required in lower quantities for production.

Q: During heat stress time in the south of China, do you recommend adding some MET to the High1 cow? How many dosage it is? (We have 20,000 cows)

Brian: Many cows in China are supplemented with MET (MetaSmart®) during heat stress to mitigate the drop in milk protein in summer which can be heavily penalized. The daily dose of dry MetaSmart will be 20 to 40 grams depending on the methionine limitation in the diet relative to metabolizable lysine status.

Q: Would the urine N analysis be a good tool to evaluate N efficiency?

Mike: It could be but is difficult to implement on a farm for a large group of cows, which is why we developed prediction equations for the model. The equations are very robust, within the structure of the CNCPS and allow you to evaluate the outcomes while formulating the diet as long as you have correct DMI, feed chemistry, cow descriptions and milk yield and components described. Higgs et al. 2012 J. Dairy Sci is where the equations are published.

Q: The current CNCPS model often predicts deficiencies in leucine and isoleucine, among other AA. How does version 7 address this? Have requirements changed, feed characterizations, etc.?

Mike: Good question. The feed chemistry will be the same as the current characterizations make sense as long as we employ the uNDF measurement for forages and high non-forage fiber sources and the uN measurement for non-forage, protein containing feeds. Everything else is different in v7. New rumen model, new requirement model, new everything. We are working to get the papers out. Happy to send a copy of a dissertation that lays out most of it, if you send me an email: **mev1@cornell.edu**.

Q: I understand that ruminants have certain needs in methionine and lysine. But I was wondering if it is possible and worth the try to estimate methionine and lysine deficiencies for grazing small ruminants. How do you calculate the needs of a grazing herd?

Mike: Good question. We have determined that methionine is most likely first limiting in grazing dairy cows based on some work from NZ by Ryan Higgs and in Ireland by Mike Dineen. So, I would assume methionine is first limiting in grazing sheep and goats during lactation.

Q: Can I use blood test to check AA balance?

Mike: We do not believe that under normal herd feeding conditions that blood tests are good evaluations of amino acid supply or levels relative to requirements. The levels would be too low and variable to be able to make good estimations. Cow performance is the metric we focus on, and that means understanding what is first limiting production.

Q: Would the same ratio targets be applicable in an NRC environment?

Brian: Because the supply part of the model is different in NRC vs CNCPS, the optimum ratio of LYS to MET is 3 to 1 in NRC vs 2.69 to 1 in CNCPS vs 6.5.5. The ratio is only important once you have optimized LYS as a % of MP in NRC (Target 6.83) or MET as g/Mcal of ME (Target 1.14 in CNCPS v 6.5.5).

Q: In your opinion, how negative in MP balance can you go with CNCPS when diets are appropriately AA balanced with respect to energy?

Mike: If you are using v6.55, I'm not sure I would go to negative on MP based on all of our evaluations. The MP prediction is still pretty solid although we know it is not "right" for many reasons. I would be as close to 100% on MP balance and then the methionine and lysine deficiencies are usually pretty obvious. Just need to make sure the rumen N balance is at least 120% when you pull the MP balance down to ensure the rumen N balance remains positive throughout the day.

Q: Is any adjustment in AA supplementation necessary in diets with higher levels of fat?

Mike: We are not aware of any reason to do that yet. Changes in milk fat are not always followed by changes in protein. As a metabolic fuel, fat does not provide a lot of ATP for protein synthesis, but it might spare some glucose and amino acids from oxidation, which would provide greater availability for lactose and protein. This area is just getting some good work, so we are paying attention to what Adam Lock and Joe McFadden are doing. We are all having conversations about integrating some of their fat signaling work into the CNCPS. Stay tuned!

Q: What should be the ideal digestibility of blood meal?

Mike: I am not sure there is an ideal digestibility for any ingredient. The best blood meal in the world (that I am aware of) is highly processed and is 91% intestinally digestible and very expensive. The average blood meal is between 70% and 80% digestible. If I find a source that is 80% or just slightly higher, I think that is good. If there was an ideal, 82% to 85% would be great.

Q: How will we relate the profile of arginine to the milk yield? Does it have any effect regarding fat yield?

Mike: We are very interested in the role of arginine in lactation and milk yield. It is not really an essential amino acid for milk yield per se but is used extensively in the gland for many other molecules that are used as intermediates and cell structure proteins or amines along with nitrous oxide production. We hope to evaluate it over time, once we make sure we have the g/Mcal of energy details worked out.

Q: In one of the trials (Basal vs +M vs MU vs Positive) milk fat decreased in +M treatment. Do you have any explanation why Met decreased milk fat? Sometimes Met increased milk fat and sometimes not? What would be the biology behind that? Does the model take into account the source of energy (Fat vs C3) in the prediction?

Mike: In that particular study, the cows experienced significant heat stress, so the fat percent and fat yields are low by our standards and not what was expected. The cows followed the data of Baumgard very well with respect to lowering fat output due to high temperatures and the shift in circulating NEFA and altered insulin status. To your question about what do cows do with amino acid N and C, my perspective is they use it to improve overall energetic efficiency and fill whatever metabolic pathway that will accomplish that outcome. So, we have observed cows increasing milk volume, milk fat and or milk protein with amino acid supplementation. That clearly shows they use energy more efficiently once the limiting nutrient is removed, but they don't do it in a linear fashion. To the last question, yes, we are considering gluconeogenic vs acetogenic diets or energy sources and are working that out right now. That was the basis of the last study I described during the webinar.

Q: Does the model take into account the source of energy (Fat vs C3) in the prediction?

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Q: When you calculated %MET and LYS, there are quite a difference between CNCPS and NRC. May you make a comment about it? And in the field, it is widely used - AA as a % of metabolizable protein - do you think we should rethink this expression?

Brian: The field recommendations for MET and LYS as a % of MP have worked well for the past 20 years. But in order to become even more accurate and efficient in the use of AAs for best cost formulation, we should now connect AAs with energy as they do in swine.

Q: In some diets, I notice a leucine lack, your opinion?

Mike: If you mean in our diets for our experiments on v7, yes, we are still learning how to formulate, or better, how to ensure that the amino acids we formulated are actually delivered to the cow. No one has formulated for all essential amino acids before, so we are learning how to organize ingredients in the diet to ensure we meet all the requirements. If you are referring to v6.55, we are not to that level of modeling in that version, so we stick to methionine and lysine where we feel very comfortable and then focus on MP.

Q: How to increase milk protein in the summer?

Mike: Under heat stress conditions, it is more difficult to increase components, so cooling cows and plenty of water are primary. Then making sure the methionine levels are kept at optimums and fermentable carbohydrates are maintained at high but healthy levels to drive propionate production. Some of this might be confounded by the change in insulin sensitivity within the cow during the summer, and I haven't worked out how that might impact protein like it affects fat metabolism.

Q: What experience do you have with AA balancing in dairy farms that graze?

Mike: We have done a couple studies in New Zealand and Ireland, and it looks as though methionine is first limiting in those conditions, so adding some RP methionine to the diets could be useful for increasing milk solids per hectare.

Q: Talk about manipulation of milk protein % and casein % with focus on energy and AA supply.

Mike: Anytime we talk about manipulating milk protein we are almost always talking about casein, so the keys are high propionate production, good rumen fill with digestible carbohydrates, and adequate digestible aNDFom, and supplying methionine and lysine to ensure the requirements are met. The amount of amino acids to add to some diets that are adequate on energy is sometime daunting and expensive if we don't have good sources or escape protein with good digestibility and amino acid profile. It is important to understand how much MP can be derived from some of the escape protein sources we have available in each market and how consistent they are. I have observed diets that are adequate on ME and close to adequate on MP that are 15-18 g deficient in methionine, which means you will never increase protein without adding at least 20 to 25 g of Smartamine and 40 g lysine.

Q: I've read recommendations for using amino acids, and the relation between Lys and Met, and also the relationship between both AAs and Met Protein (2.5% & 7%) and relation of AAs and Met energy. Which of all these relations is the good one?

Mike: We are working to move away from percentages as a good percentage could still leave you short on grams. If you are using a CNCPS based model, 1.15 to 1.19 g methionine per Mcal ME is the best approach and then multiply that methionine outcome by 2.7 to get the lysine requirements. These numbers on an EAA basis are about 5.7% EAA for methionine and 15.1% for Lysine, which is consistent with the previous percentages, but it is important that you have met the gram requirement too.

Q: How do you weigh the cows without an electronic scale? Can you use tape weight? Do you do any kind of adjustment based on BCS?

Mike: We weigh cows any way we can. It is the most important variable in all of this. Tape weights are great if that is what you can do. Electronic scales are very good, but you have to make sure they are calibrated and load cells are working properly. We see this piece of equipment on some farms not be maintained adequately. We do not adjust for BCS but within the model consider what a BCS means to BW if you are modeling changes in BCS. So, if you have changes to input, the CNCPS/AMTS/NDS/DALEX/DINAMILK have an input for target and current BCS and days to change. This will allow you to characterize the energy mobilized or accreted over the period.

Q: When we´re formulating with AAs, can we be lower in MP?

Mike: If you are using v6.55, I'm not sure I would go to negative on MP based on all of our evaluations. The MP prediction is still pretty solid, although we know it is not "right" for many reasons. I would be as close to 100% on MP balance, and then the methionine and lysine balance can follow. I have observed diets that are adequate on ME and close to adequate on MP that are 15-18 g deficient in methionine, which means you will never increase protein without adding at least 20 to 25 g of Smartamine and 40 g lysine. Again, I would use 1.15 to 1.19 g methionine per Mcal ME and then multiply that result by 2.7 to get the grams of lysine required.

Q: What could be the range between AAs and MP where we can see the effect of adding protected AAs?

Brian: The best use of protected AAs are as ingredients through formulation. They should not be treated as feed additives. They will be pulled into formulations to meet requirements for optimum production, metabolic health, and reproduction based on the cost per unit of metabolizable methionine and or lysine. As a general rule, formulating for MET and LYS will allow you to economize MP levels as demonstrated by many trials where MP balance is negative due to the cows outperforming the predicted MP allowable from the ration.

Q: Regardless of the milk market, do you formulate for ECM?

Mike: Yes, I always formulate on ECM because it represents the overall energetic efficiency of the cows and diet. I find it difficult to push milk volume and be deficient on amino acids or fatty acids. Those are all requirements for milk synthesis, so ensuring all requirements are met is essential for good feed efficiency, reproduction, and health.

Q: Do you believe that the same effect of insulin (propionate and glucose) on mammary gland synthesis can be achieved by a greater supply of fatty acids?

Mike: We are not aware of any data demonstrating that yet, and I am not sure it is a viable option as lactose is dependent on glucose and propionate. It is possible that some fatty acids are part of the signaling pathways, and I am working with Joe McFadden to help understand where some of this might be relative to milk yield.

Q: If ME is so important, do we have a range between Lys & Met and ME or do we need to be so accurate with the values of 3.03 & 1.14?

Mike: The data we have generated are telling us we need to be at those gram amounts to make this all work. Yes, there is a range, but when we dropped down one standard deviation on amino acids, the cows told us that was not good. When we went up one standard deviation, there we no real change in milk protein or fat, so it seems for high-producing lactating cows the values are reasonable. As we learn more, we might determine there is some wiggle room for particular amino acids, but right now we are sticking with the values described.

Q: If I use RP-Met or RP-Lys products for fresh and peak cows only, is there any productivity or health issues on the same cows if I did not use the same products for the same cows at other periods of the lactation cycle?

Brian: If diets are only enriched with LYS and MET for a limited period pre- and postpartum, productivity will be impacted after supplementation is curtailed as both amino acids continue to be required as building blocks for all milk protein synthesis and all the other proteins/ enzymes needed for normal bodily functions. Reproduction may also be negatively impacted, as it has been shown that it is necessary to maintain high MET levels until cows are confirmed pregnant at 60 days to mitigate embryonic losses. The last webinar in the series by Dr. Phil Cardoso at the University of Illinois will provide more details.

Q: Can we use Rhodimet 88 as a source of methionine for ruminant?

Brian: **Rhodimet® AT 88** or Alimet® should not be considered protected methionine sources. The role of HMTBa that they provide is in the rumen to mitigate milk fat depression.

Q: Why do you focus more in the lysine in the fact that the level of methionine IN ALL raw material is lower than lysine?

Mike: We are focusing on all essential amino acids, not just lysine. Methionine requirements have to be met first, then lysine. Start with 1.15 to 1.19 g of methionine per Mcal ME and then take the solution to that and multiply by 2.7 to get the lysine requirement if using v6.55.

Q: What is your opinion on the use of NDF digestibility rates from NIRS analysis, when thinking about optimizing microbial protein prediction in the rumen?

Mike: It depends on the lab you are working with, as to how good the NIR rates are being predicted or calculated. They can be very useful, or they can be very problematic. If the lab has a system by which they are always recalibrating, testing, and rerunning their data against new and existing data, then it might be ok. It is also important that the lab has good wet chemistry data, and there are a couple labs in the world that do not have good wet chemistry digestibilities, so the NIR data from those values will not be useful.

Q: In grazing diets, the models tend to overestimate the contributions of forage digestible amino acids. Is there enough information to make an adequate balance in these conditions?

Mike: When adequate intake data are given to the model for cows under grazing conditions, we can get good predictions and have data from Ryan Higgs and Mike Dineen, NZ and Ireland, respectively. We just finished analyzing data from grazing cattle in Ireland where we conducted an omasal flow study. >80% of the amino acids flowing to the omasum were of microbial origin and 22% were from protozoa, so the cow has a heavy reliance on microbial amino acids and the model can do a good job of predicting that. We have data to share if you send me an email: **mev1@cornell.edu**.

Q: Can we use the propionate of calcium as a source of energy for ruminants?

Mike: You can supplement some propionate products to cattle as an energy source, but it is not economical or feasible yet to do so for cows in established lactation. Good for fresh cows to overcome some lower glucose situations, but not as a feed additive for cows producing 30 kg of milk and greater.

The answers to these questions are provided in good faith and are the scientific opinions uniquely of Dr. Mike Van Amburgh, Cornell University, and Dr. Brian Sloan, Adisseo.