Balancing for Amino Acids beyond Lysine and Methionine

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INTRODUCTION

Those of us who balance rations for a living have been balancing rations for crude protein (**CP**) for ever. Crude protein is just that. It is the total nitrogen in a feed times 6.25, which gives us an *estimate* of the protein. This assumes that protein or amino acids (**AA**), on average, contains 16 % nitrogen and 1/0.16 = 6.25, the fudge factor that we all use. This all began in the late 1800's. We still use it today – every day in balancing rations. We then decided that all CP was not created equal. We decided to measure the fractions of the protein. We started out with the bound protein, recognizing that some protein was unavailable. This was measured by analyzing the protein in the acid detergent fiber (**ADF**). This procedure was developed by Goering and Van Soest (1970). Next the measurement of soluble protein using a buffer that simulated rumen fluid came along. This was a recognition that part of the protein broke down in the rumen rapidly. The model was that this protein broke down in the rumen within an hour. We subsequently refined this into non-protein nitrogen (**NPN**) and the protein precipitated from that fraction which was comprised of large peptides and true protein extracted with the buffer. Just recently this was modified again by splitting the soluble protein into NH_3 and the remaining protein. However, it was recognized that this was only part of the protein that was degraded in the rumen.

We have evolved to a system that uses ruminal degraded protein (**RDP**) and ruminal undegraded protein (**RUP**). We have measured the RUP by *in situ*, *in vitro*, and by enzymatic procedures. We have used constants for different feedstuffs for a long time. We now recognize that the amount of a protein in a feedstuff that will be degraded in the rumen is a function of its degradability characteristics and the rate at which the feed passes or escapes from the rumen. None of this recognizes that there are differences in the quality of the proteins being fed. We are now focusing on AA nutrition in the cow in order to increase the efficiency of protein utilization by the cow. This will be the focus of discussion for this presentation.

BALANCING THE RUMEN REQUIREMENT FOR PROTEIN

In order to increase the protein efficiency for the cow, we need to first consider the efficiency of protein use in the rumen. The work recently done at Cornell and at the USDA Forage Center in Wisconsin addresses one of the basic questions about which we have made some assumptions; and that is how much dietary RDP do we need to feed? Our assumption has been that we needed 11 % of the dry matter (**DM**) as RDP. The Cornell research demonstrated that we underestimated the recycled protein returning to the rumen from the saliva and across the rumen wall. Additionally, the research pointed out that we underestimated the contributions of the protozoa to the rumen available protein. Protozoa grow up and die in the rumen with only 20 to 25 % of them washing out of the rumen. The protozoa provide a lot of peptides, that we assumed we needed to provide from RDP sources, such as soybean meal. What we are learning is that we can reduce the RDP to 9.0 to 10.5 % of the DM or maybe lower. This translates into the CP in the ration dropping by 1 to 1.5 % of the DM. Our challenge is to balance the rapidly and slowly degraded proteins with the rapidly and slowly degraded carbohydrates. An additional challenge is the efficient utilization of the urea in the ration, as well as the NH_3 and the other NPN sources in the ration. It has been recognized that bacteria that digest starch and sugars are stimulated by peptides (AA connected together which are normally the degradation products from the true protein in feeds or protozoa).

These peptides are also important because they supply isoacids from branch chain AA isoleucine, leucine, and valine; which are required by the bacteria that digest fiber. So, indirectly, this suggests we should be balancing for rumen degraded AA. Recent work has shown that the bacteria might require methionine. This has resulted in the Novus group recommending the use of Alimet, a methionine analogue, to meet the rumen requirement as well as a bypass methionine source, which we will discuss later. This then poses the question whether certain bacteria have additional AA requirements that we have not identified. The goal, of course, is to optimize microbial growth, which will optimize carbohydrate fermentation and the production of the

fermentation acids that the cow depends on for energy (propionate) and milk fat synthesis (acetate and butyrate).

The key is the synchrony of the protein (NPN, AA, and peptides) available in the rumen with the growth rate of the bacteria digesting the various carbohydrate fractions in the feeds that we provide to our dairy cows. There have been many studies done on this, but unfortunately most of these studies have utilized nutrition models too simplified to ask the right questions. The CPM Dairy 3.0 model (CNCPS 5.0 based) and Dalex, based on the CNCPS/CPM model, have expanded carbohydrate models in them; which allow us to ask better questions about synchrony. These models define silage acids, sugars, starch, soluble fiber, and available insoluble fiber. Workers at Cornell recognized the importance of the CPM expansion and expanded the CHO model further by separating lactic acid from the silage acids and plant organic acids from the soluble fiber; making the soluble fiber more uniform as well as potentially identifying unique organic acids like malic acid, which stimulates bacteria that utilize the lactic acid made in the rumen, reducing the potential for acidosis. Additionally they discovered that a redefinition of the protein fractions can occur that will potentially allow us to better synchronize the protein and CHO degradation in the rumen; maximizing microbial yield and minimizing protein wastage, in the form of ammonia, going to the bloodstream and to urea. This work could result in a big step forward.

MEETING THE AMINO ACID REQUIREMENTS OF THE COW

Meeting the AA requirements of the cow starts with optimization of the microbial growth in the rumen and the subsequent flow of the microbial mass to the small intestine. Our current nutrition models are doing a better job of predicting this flow of bacterial DM to the small intestine, but there still is a ways to go. Table 1 contains the analysis of the microbial mass flowing to the small intestine that is assumed in CPM Dairy. This is a high protein entity; but you need to note that 25 % of the protein is cell wall protein, which ends up in the feces. The nucleic acids are absorbed, but are not utilized. The true protein is assumed to be 100 % digestible. The bottom line though is that the actual protein, on a DM basis, that is useable, is 37.5 % DM; a lot lower than the 62.5 % with which we started.

Table 1. The analysis assumed in CPM dairy of the microbial mass flowing to the small intestine.

Parameter	Value
Bacterial protein, % DM	62.50
Bacterial nucleic acid, % CP	15.00
Bacterial true protein, % CP	60.00
Bacterial cell wall protein, % CP	25.00
Bacterial carbohydrate, % DM	21.10
Bacterial fat, % DM	12.00
Bacterial ash, % DM	4.40

The question then is "What is the AA content of the bacterial true protein?" Table 2 has the assumptions for the AA content of not only the bacterial protein but also tissue and milk in g/g of tissue protein, milk true protein and bacterial true protein. To calculate %, multiply the numbers by 100. There is disagreement regarding the AA content of these 3 entities. For example, it is suggested that the tissue Arg content is 0.0667 and bacterial Arg content is 0.060 g/g. This frequently translates into a deficiency for Arg, using the factorial approach.

Table 2. The amino acid content of tissue protein, milk true protein, and bacterial true protein in grams of amino acids per gram.

Parameter	Tissue Protein	Milk True Protein	Bacterial True Protein
	----------g of AA/g----------		
Methionine	0.0197	0.0271	0.0268
Lysine	0.0637	0.0762	0.0820
Arginine	0.0330	0.0340	0.0696
Threonine	0.0390	0.0372	0.0559
Leucine	0.0670	0.0918	0.0751
Isoleucine	0.0284	0.0579	0.0588
Valine	0.0403	0.0589	0.0616
Histidine	0.0274	0.0274	0.0269
Phenylalanine	0.0353	0.0475	0.0516
Tryptophan	0.0049	0.0151	0.0163

There have been studies that show that correcting the Arg deficiency resulted in an improvement in animal response. However, many studies done on grass-based rations using barley and canola show that histidine was first limiting. It can be seen, looking at the bacterial AA profile relative to the milk AA profile; that Met, Leu, and His are marginally low.

We spend a lot of time on essential AA, mostly focusing on Met and Lys. We need to also place considerable emphasis on meeting the MP requirements of the cow. We cannot forget that a significant part of the MP are the non-essential AA. Yes, the cow can synthesize these AA; however cows still have a significant need for these AA to make glucose and to help meet the synthetic requirements for tissue and milk.

We now come to the area of knowing what the efficiency of utilization of AA are at the small intestine. How much does the gut take out before it gets to the liver and then what does the liver do to the AA before they get to the tissues and to the mammary gland?

Helene Lapierre, Ag Canada, Lennoxville, Canada groups the AA into 2 main groups. Group 1 is extensively catabolized by the liver and the supply to the mammary gland is approximately equal to their secretion in milk protein. In contrast group 2 has little if any extraction by the liver and the supply to the mammary gland is greater than the extraction and greater than the secretion in the milk protein. Note that Thr and Arg are not listed. Threonine is not clearly in either group and it is suggested that Arg is synthesized in adequate amounts not to be classified as an essential AA. This is in contrast to other work suggesting that there can be rations where Arg is limiting.

Group 1 – catabolized by the liver

- Histidine
- Methionine
- Phenylalanine
- Tyrosine
- Tryptophan

Group 2 – little liver extraction

- Isoleucine
- Leucine
- Valine
- Lysine

In contrast many researchers have looked at AA from an energy mediated active uptake, categorized the AA by their chemical entities, and observed uptake behavior at the tissue based on their acidity classification, into 1 of 3 major groups (Figure 1).

Neutral

Aliphatic

Threonine
Leucine
Valine
Isoleucine

Aromatic

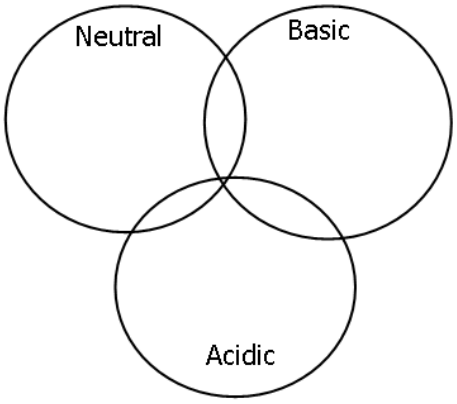
Phenylalanine

Sulfur containing

Methionine
Cystine/Cysteine

Heterocyclic

Tryptophan



Basic

Histidine
Arginine
Lysine

Acidic

All other amino acids

Figure 1. Schematic of the three major groups of amino acids depicting an overlap.

Many of the non-essential AA fall into the acidic groups. It will be noted in Figure 1 that there is an overlap of the 3 proposed major sites. This approach suggests that if we have an abundance of say Met it will inhibit the uptake of other AA in its group and can inhibit the uptake of other AA in other groups. We have had experience that if Met is excessive relative to Lys performance is reduced, suggesting that there is an inhibition of Lys uptake.

The whole approach to formulation for AA is still controversial. With the factorial approach, Lapierre (2007) has suggested decreasing the efficiency as the AA being absorbed gets closer to the optimum. This makes sense from a biological perspective. She put the maintenance requirement and mammary requirement together to come up with changes in efficiency for each AA. This approach definitely needs to be examined carefully to compare to the ideal protein approach.

In platforms that formulate for AA (Amino Cow, CPM, CNCPS 6.1, AMTS Cattle, NDS, DinaMilk, Dalex, and NRC 2001) that are available for purchase (Amino Cow is available from Degussa or now Evonik, by asking), the approach is to estimate the requirements based on a factorial system. This approach uses the AA analysis of the product (meat or milk) and the efficiency of utilization of the absorbed AA for making the target protein. A problem can occur however in that the AA in Group 1 are actively metabolized by the liver; which can result in a different blood concentration being presented to the mammary gland or muscle than what is absorbed. In the case of milk protein, the assumed efficiencies of utilization in Table 3 are used in CPM Dairy (CNCPS 5.0). If one agrees that Lapierre is correct; then the efficiency of utilization of these AA will decrease as the amount of any one of these AA supplied increases to requirement and exceeds requirement..

Her data show a linear decrease in efficiency as the supply increases. In fact this might be correct; however, as shown above, if the work of Rulquin and others are correct, then from a response side there can be optimum ratios of AA relative to the total absorbed protein. Of course, this becomes a little risky, because we are then assuming some constant efficiency of utilization of the protein in the small intestine.

In the CNCPS model there is an attempt to separate the protein into different fractions. The C fraction (ADF protein) is totally unavailable. The soluble protein fraction is assumed to be almost all digested in the rumen and then there are 2 additional fractions, B2 and B3, which have variable rates of escape from the rumen. In an attempt to differentiate the quality of these two fractions; B2 was assumed to be a high quality protein with 100 % digestibility in the small intestine and the B3 fraction was assumed to be lower quality with 80 % digestibility. This was a beginning approach. In the NRC swine model, there is more specific digestibility variation of AA by protein source. We have a ways to go yet in doing that in dairy models.

Table 3. The efficiency of amino acid utilization by target tissues for differing functions in grams of amino acids per gram.

Parameter	Maintenance	Gain	Pregnancy	Lactation
	----------g of AA/g----------			
Methionine	0.8500	0.3104	0.8500	0.9800
Lysine	0.8500	0.3104	0.8500	0.8800
Arginine	0.8500	0.3104	0.6600	0.4200
Threonine	0.8500	0.3104	0.8500	0.8300
Leucine	0.6600	0.3104	0.6600	0.7200
Isoleucine	0.6600	0.3104	0.6600	0.6200
Valine	0.6600	0.3104	0.6600	0.7200
Histidine	0.8500	0.3104	0.8500	0.9000
Phenylalanine	0.8500	0.3104	0.8500	1.0000
Tryptophan	0.8500	0.3104	0.8500	0.8500

Table 4. Amino acid recommendations derived from various models expressed as absorbed AA, percent of metabolizable protein (Adapted from Chalupa and Sniffen, 2005).

Amino Acid	Sniffen et al., 2001	Doepel et al., 2004	Rulquin et al., 2001	Rulquin, 2008[1]	Rulquin, 2008[1] Ideal To Lys	NRC, 2001	Average Not Rulquin, 2008	Your Ration		Balances, % Req.	
								RR[2]	g Bal	RR	g
Met	2.02	2.5	2.5		2.48	2.38	2.35				
Lys	7.05	7.2	7.3		7.30	7.24	7.20				
Arg	6.22	4.6	>4.3				>5.04				
Thr	4.54	5.0	>4.3	5.5	4.02		>4.61				
Leu	8.37	8.9	<8.8	<8.0	8.91		<8.69				
Ile	4.73	5.3	>5.0				5.01				
Val	5.75	6.5	>5.3	>5.8	5.91		>5.85				
His	2.72	2.4	3.2	3.8	3.07		2.77				
Phe	5.10	5.5	4.9-5.0		4.6		4.9-5.1				
Trp	1.37	-	Not limiting				<1.4				

[1]For reference only – not included in the **Average**
[2]Rulquin Ratio - % MP

Table 4 illustrates the second approach in formulating rations, the ideal protein approach. This approach has been used in the swine and poultry models for a long time. Rulquin, INRA, France, first suggested this approach many years ago. Chuck Schwab, UNH, originally developed an ideal protein approach that expressed Lys and Met as a percent of the protein in the small intestine. Later, when on the NRC 2001 committee, he changed this to be similar to the Rulquin approach, expressing these 2 AA as a percent of metabolizable protein (**MP**).

This approach essentially agrees with Lapierre (2007), that there are changes in efficiency. However the contrasts are 2-fold: First the data suggest that in terms of milk protein synthesis and milk volume, the response is non-linear. Next, there is the tacit admission that at this point there is a lack of quantifiable relationships to develop a factorial system. The original data in this table were from Sniffen et al. (2001), Rulquin et al. (2001), and NRC (2001). The Doepel et al. (2004) data are from a paper cited and used in Lapierre's paper (2007). The one dataset that is totally independent of the others is Sniffen et al. (2001). This dataset was from 22 studies conducted in Canada and the USA with a large diversity of rations. The fascinating part of these data is that the optima for the AA are all reasonably similar. The column on the right is an average, suggesting that as we evaluate rations we should attempt to achieve these optima. Amino acids without a less than or more than symbol suggest that the response curve is fairly flat. Those AA with a less than symbol suggest that one should not go over the amount indicated. Those with a greater than symbol, suggest that we should try to achieve at least that concentration. Phenylalalanine is unique in that it has a fairly narrow window that says one should keep within these concentrations. We really have had experience with only 2 AA – Met and Lys. This is because of the initial recommendations developed by Rulquin (2001) and NRC (2001); which was coupled with extensive research and field experience. The only other AA that has significant research behind it is His, with most of that work done in Finland using grass, barley, and canola based rations.

We have learned 2 things with Met and Lys. We cannot achieve the recommendation of NRC (2001) and Rulquin (2001) for Lys. We can get to 6.6 to 6.8 % MP. We have learned that when we achieve this level, we get a response in milk or protein or both. We also learned that we could not achieve this response without increasing Met as well. The second thing we learned was that we needed to be careful in supplying Met. If we fed too much Met, which is easy to do with rumen protected Met, we can get a reduced response in milk. We learned that we needed to keep the absorbed Lys:Met ratio above 3:1.

What about the other AA? We just have not had the experience with them. The research that we conducted with both protected Lys and Met demonstrated that when we did not get a good response, some of the AA ratios suggested were at a less than optimum ratio. We still have a lot to learn. It is suggested that as we move forward, we will learn more about the biology and be able to develop more

sophisticated dynamic models that will use the factorial approach; which should be more sensitive in predicting responses.

The right side of Table 4 is for the input of the producer's ration both for the ideal protein approach and the factorial calculations. These are used with nutritionists so that they can put in the gram balances and then also calculate the balances as a percent of the requirements, either with the ideal protein or the factorial approach; whichever the nutritionist is more comfortable.

FIELD FORMULATION – WHAT CAN YOU DO?

We have talked quite a bit about some of the things happening in the AA area and about the theories. We have been hearing from Dr. Glenn Broderick (2007) at the Forage Lab in Wisconsin about reducing the protein in rations and increasing protein efficiency. There is a big push from the federal Government to control N going into our aquifers and the air. We need to address this.

We wish we had a simple answer to the problem, such as "Just formulate for AA and your problems are solved." Afraid that this will not work. This paper started with the rumen. We have to start there again. We have to start with the forages on the farm, which usually means corn silage and alfalfa silage. These forages become the major effective fiber sources. Unfortunately these 2 forages are not great effective fiber sources. The reason for this is 2-fold: first we have put so much emphasis over the last 30 yr on growing quality forages that we are producing alfalfa with 22 to 24 % CP and with NDF less than 40 %. With corn silage, we again have emphasized grain yield and have ended up with corn silage less than 40 % NDF. We have also placed a lot of emphasis on growing a lot of alfalfa and not much corn silage. Luckily this has changed in the last few years. Second when alfalfa is made into silage with 38 to 40 % NDF, the fiber just is not that effective. Next, when we look at corn silage, the forage particles are just not that good in forming a mat in the rumen. Bottom line we have 2 forages that are just not that good in supplying effective fiber, and for healthy cows we need effective fiber.

Our solution, of late, is feeding straw. This is a grass which is effective in rumen mat development (if chopped properly) and has a lot of chewing time per lb of NDF. So we put in 1 to 2 lb of straw. Unfortunately, this is becoming expensive for many producers. If you have a 50:50 mix of alfalfa and corn silage, this gives you a forage base of 14 to 15 % CP. We like the corn silage and alfalfa mix to come out less than 14 % CP. Look at the average proteins in the corn silage and alfalfa over the last few years and determine what blend is needed to achieve that. This provides guidance for future plantings. This constraint is used because we are trying to control protein degradability in the rumen and the resultant CP in the ration. If the ration is at 18 % CP now, there will be an opportunity to move to a 17 % CP ration. Another possibility is to either grow or buy grass. Grass would be 10 to 14 % CP with the NDF over 60 %. Grasses, chopped right, do an excellent job of making a mat in the rumen and help control the CP in the ration. It should be added that there are some new varieties of triticale and sorghum-sudan crosses that provide great yields and high fiber digestion, ensuring good rumen mat formation.

Meeting the metabolizable energy (**ME**) requirement is important. We recognize that early lactation cows will be in negative energy balance and will metabolize AA for energy. Our limited research shows that if we have adequate MP in the prepartum period the negative ME will not impact milk protein as much. Bottom line is meet the ME requirement as best as we can.

The next challenge is to balance the degradable protein in the forages with the fermentable CHOs that are being fed. This is a bit tricky. Our beginning guideline is to have a ration with 30 to 35 % of the CP as soluble. In our sophisticated models (NRC and CNCPS), we balance for the NPN and the peptides. Lately we have been balancing for 95 to 100 % of the peptide requirement in the CNCPS model; which is achievable when alfalfa silage is less than 50 % of the total forage being fed and very difficult to accomplish if it is greater than 55 % of the total forage (good alfalfa silage has a lot of peptides). This provides the opportunity to build rations balanced for 100 lbs of milk with 17 % CP. On the CHO side we need a mixture. We start with a reasonable quality digestible fiber source, meaning good digestibility fiber from corn silages or sorghum silages and from the hay crop. Remember, we need to have a balance of indigestible and digestible insoluble fiber to maintain the mat and good chewing. Next we need a balance of fermentable starch sources. Corn silage or sorghum silage provides the biggest source of potentially rapidly fermented starch. We need to be careful here. We are finding that the starch in recently stored silage has a low

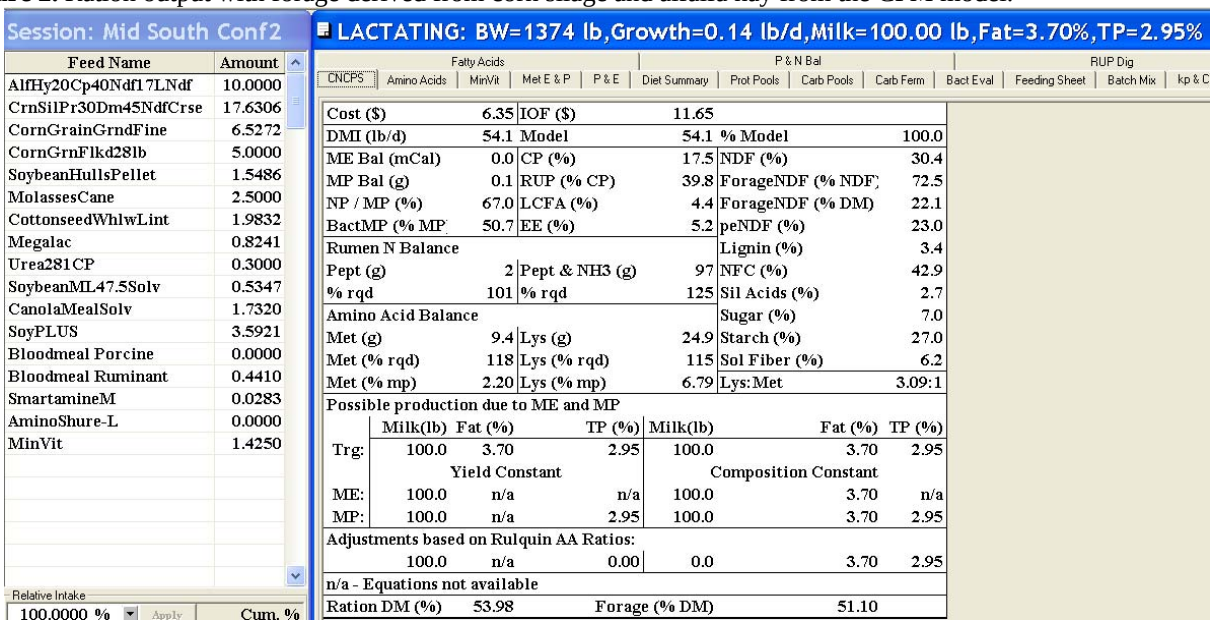
fermentability. It is assumed that the same occurs with sorghum silage. After 4 to 6 mo, depending on DM at ensiling and hybrid, the starch will be highly available. Ground corn has a lower fermentability in the rumen than we use to believe. Steam-flaked corn and sorghum have a much higher fermentability in the rumen. This is important because we need to be reasonably accurate at predicting microbial AA so that we can intelligently supplement the ration. We need about 21 to 24 % fermentable starch in the ration DM. We also need at least 5 % sugars in the ration for optimal utilization of the rapidly degraded N. We can balance the fermentable starch with the soluble fiber, which breaks down rapidly in the rumen. Depending on the starch sources and the environment surrounding the cows, 5 to 9 % soluble fiber is desirable. Our goal is to optimize the utilization of the RDP in the rumen, making sure there is enough to optimize microbial growth, but not excess that will be lost from the rumen as ammonia.

A challenge that we have as nutritionists is the day-to-day consistency of forages. On many of the farms that we work with consistency is poor. To cover ourselves we drop the forage in the ration and over formulate on protein. The closer the control on the forages, the higher the forage in the rations and the lower the protein in the ration.

We have learned many things on the metabolism side, but have a long way to go in the AA area. The approach that has worked reasonably well up to now is this - *balance to meet the MP so that the net protein requirements are met.* We have been assuming in CNCPS that 65 % of the MP provided for lactation will be used for milk synthesis, including milk protein. NRC uses 67 %. The new CNCPS 6.1 is 67 %. At times this is actually significant, and results in a 0.5 to 1 % reduction in CP. To be extreme, if the bypass protein is coming from corn gluten meal and distillers grains, as the major supplemental bypass protein sources; then we should question using an efficiency of 67 %. However if we balance the AA, a 67 % efficiency could be reasonable. If we go the next step of trying to optimize the other AA, then we might consider that the efficiency could be moved to 70 %. This means less protein being fed and we approach the optimum that Dr. Lapierre talks about.

Figure 2 is a ration (on a DM basis) that uses corn silage at 64 % of the corn silage/alfalfa hay. With a peNDF (effective NDF) of 23 % and forage NDF of 22.1 % (we consider 22 % as adequate) with 51.1 % forage in the ration, we can achieve 101 % (maxed) of the peptide requirement. The NH_3 requirement is at 125 % (Min) giving a RDP of 10.5 %, which we now think is reasonable. It may be possible to fine tune this lower, watching cow response. The goal in the CPM model (CNCPS 5.0 based) is to have 50 % of the MP coming from

Figure 2. Ration output with forage derived from corn silage and alfalfa hay from the CPM model.



Session: Mid South Conf2

Feed Name	Amount
AlfHy20Cp40Ndf17LNdf	10.0000
CrnSilPr30Dm45NdfCrse	17.6306
CornGrainGrndFine	6.5272
CornGrnFlkd28lb	5.0000
SoybeanHullsPellet	1.5486
MolassesCane	2.5000
CottonseedWhlwLint	1.9832
Megalac	0.8241
Urea281CP	0.3000
SoybeanML47.5Solv	0.5347
CanolaMealSolv	1.7320
SoyPLUS	3.5921
Bloodmeal Porcine	0.0000
Bloodmeal Ruminant	0.4410
SmartamineM	0.0283
AminoShure-L	0.0000
MinVit	1.4250

Relative Intake: 100.0000 % Apply Cum. %

LACTATING: BW=1374 lb,Growth=0.14 lb/d,Milk=100.00 lb,Fat=3.70%,TP=2.95%

Fatty Acids | P & N Bal | RUP Dig

CNCPS | Amino Acids | MinVit | Met E & P | P & E | Diet Summary | Prot Pools | Carb Pools | Carb Ferm | Bact Eval | Feeding Sheet | Batch Mix | kp & C

Cost ($)	6.35	IOF ($)	11.65		
DMI (lb/d)	54.1	Model	54.1	% Model	100.0
ME Bal (mCal)	0.0	CP (%)	17.5	NDF (%)	30.4
MP Bal (g)	0.1	RUP (% CP)	39.8	ForageNDF (% NDF)	72.5
NP / MP (%)	67.0	LCFA (%)	4.4	ForageNDF (% DM)	22.1
BactMP (% MP)	50.7	EE (%)	5.2	peNDF (%)	23.0
Rumen N Balance				Lignin (%)	3.4
Pept (g)	2	Pept & NH3 (g)	97	NFC (%)	42.9
% rqd	101	% rqd	125	Sil Acids (%)	2.7
Amino Acid Balance				Sugar (%)	7.0
Met (g)	9.4	Lys (g)	24.9	Starch (%)	27.0
Met (% rqd)	118	Lys (% rqd)	115	Sol Fiber (%)	6.2
Met (% mp)	2.20	Lys (% mp)	6.79	Lys:Met	3.09:1

Possible production due to ME and MP

	Milk(lb)	Fat (%)	TP (%)	Milk(lb)	Fat (%)	TP (%)
Trg:	100.0	3.70	2.95	100.0	3.70	2.95
	Yield Constant			Composition Constant		
ME:	100.0	n/a	n/a	100.0	3.70	n/a
MP:	100.0	n/a	2.95	100.0	3.70	2.95
Adjustments based on Rulquin AA Ratios:						
	100.0	n/a	0.00	0.0	3.70	2.95

n/a - Equations not available

Ration DM (%) 53.98 Forage (% DM) 51.10

BactMP – this is up in the upper left hand corner and was achieved. Looking further at the CHO panel, we have a 27 % starch (Max - OK in the winter under good feeding management), 7.0 % sugar, and 6.2 % soluble fiber. This is a good mix. This ration was formulated on a least-cost basis, with restrictions placed on the alfalfa coming into the ration based on inventory constraints. Other ingredients had maxes on them and were hit, such as WCS and molasses. The formulation was for (see the top of the screen shot in Figure 2) a 1374 lb cow producing 100 lb of milk containing 3.7 % fat and 2.95 % true protein. The ration, with the cows eating 54 lb of DM, met the ME requirement and the MP requirement at 67 % MP efficiency for lactation. The ration is a 17.5 % CP ration. Broderick (2007) has shown nice responses with 16 % CP rations . Van Amburgh et al. (2007), with an all corn silage based ration, achieved 100 lb with a 14 % CP. Obviously there is an opportunity for improvement in the biology of the model. Because of the good fermentation of the ration, the microbial protein yield was high; which generated the microbial Lys and allowed a positive 25 g balance of Lys. This also allowed the Lys as a % MP to be at 6.96 %. We try to achieve 6.8 % of MP. Then we place a constraint on Met to meet a Lys:Met ratio of greater than 3:1. In the above situation we are at 3.09:1 and could have been more aggressive on the Met, possibly down to 2.9:1 given some of the latest observations. The other criterion is to achieve a point where the Rulquin et al. (2001) adjustments are at or above 0. Understand that the formulation is for 100 lb of milk and 2.95 % TP. This results in an increased cost, which requires a return in milk and components. Will just balancing for Lys and Met ensure increased response? This brings us to the earlier discussion about the optimum ratios of the other AA. Based on research previously mentioned, there is a good possibility that this might not be the case. Work done at several Universities strongly suggests that it is important to formulate for the other AA.

Isoleusine could be increased a little, since on a factorial basis it is limiting. Phenylalanine could be decreased a little on a Rulquin basis as well as on a factorial basis. Again there is uncertainty in the appropriate efficiencies for each AA. Interestingly, adding some feather meal and expeller linseed meal to the blood meal satisfies these AA. Protein blends are the preferred route to go not only for a better AA balance, but also for quality control. What is difficult is that we would like to optimize for each AA using a least-cost balancer. With CPM this is not possible. With the latest Dalex platform and AMTS, it is now possible to do this.

Table 5. Example ration amino acid estimated profiles from the CPM model.

Amino Acid	Average Not Rulquin, 2008	Your Ration		Balances, % Req.	
		RR[2]	G Bal	RR	g
Met	2.35	2.2	9.4	94	118
Lys	7.20	6.79	24.9	94	115
Arg	>5.04	6.4	19.4	127	112
Thr	>4.61	4.76	43.5	103	147
Leu	<8.69	8.17	5.1	94	102
Ile	5.01	4.99	-6.9	100	95
Val	>5.85	5.87	23.3	100	116
His	2.77	2.81	18.9	101	131
Phe	4.9-5.1	5.18	54.8	104	159
Trp	<1.4	1.42	12.6	101	145

CONCLUSIONS

Begin by balancing the prepartum rations to minimize postpartum difficulties. Next for fresh cows and high group cows, balance the effective fiber, which helps control rumen pH and feed efficiency. Then optimize the fermentable CHO fractions to optimize ME supply and microbial protein yield, as well as enhance the efficiency of utilization of RDP, to minimize loss of NH_3 from the rumen. Finish by balancing the MP and the AA. It is suggested that we can achieve a higher percent of the protein going into milk with less nitrogen going into urine and feces and allowing us to decrease dietary protein input. Remember, that as we decrease the MP supply by formulation a reduction in the variation in the sources of protein fed to the cows must also occur, otherwise we are forced to over formulate.

We still have more to learn about digestion of AA throughout the GI tract, endogenous protein supplies, and recycled N. We have a lot more to learn about AA metabolism. We do need to go beyond Lys and Met.

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