The Practical Application of Balancing Lactating Cow Rations for Amino Acids

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Background

Nature has made the protein and AA nutrition of the cow complicated:

Background

Feeding 2 systems:

1. A bacterial that requires ammonia but can use AA
2. A mammalian that requires AA and must detoxify ammonia

Background

It is the interdependency of these two systems, as well as the inability to know exactly what each is contributing, that causes the problems with determining supply and requirements.

Background

The cow is poor at utilizing nitrogen:

only about 25-30% of intake nitrogen is used for producing milk, meat or offspring.

Most of the remaining is excreted in urine and contributes to environmental pollution

-and more stringent regulation is coming.

Background

Studies are lacking:

There are 100's of studies on AA nutrition, but they are almost all of a Latin square design.

Short term lots of things can be masked—long term has devastating effects on production.

Background

- Need long term studies to determine real effects of AA balance and supplementation
- Right now we have ideas of what is correct, not many real studies.

Background

Goals for today:

1. Talk about new knowledge of AA use supply
2. Discuss some studies
3. Make some balancing recommendations

The Essential AA

- For dairy cattle there are 9 EAA
  His, Ile, Leu, Lys, Met, Phe, Thr, Trp, Val

Arg can be synthesized by the cow, but perhaps not in sufficient quantities under high production and disease (?)

- more properly called provisionally essential

The cow as well as the microbes can make non-essential AA from EAA

The total of NEAA + EAA = MP

The Essential AA

We need to supply both the total AA (MP) and the EAA to supply the metabolic demands of the cow:

- Maintenance
- Growth
- Reproduction
- Milk production—dominant drain of AA in lactating cow

Microbial Protein

- Rumen bacteria can make all AA that the cow needs: both EAA and NEAA
- Rumen microbes normally make up about 50-75% of total AA arriving at duodenum
  - 45-60% bacteria
  - 10-15% protozoa

Microbial Protein

Item	Arg	His	Ile	Leu	Lys	Met	Phe	Thr	Trp	Val	EAA
Milk	3.3	2.8	5.7	9.9	7.9	3.0	5.0	4.1	1.4	6.6	49.7
R. Bact	5.1	2.0	5.7	8.1	7.9	2.6	5.1	5.8	-	6.2	49.8
R. Prot	3.5	1.5	5.5	6.7	8.2	1.7	4.7	4.4	-	5.2	42.7

Rumen bacterial protein is most like milk protein

-lacks only His and Met, perhaps a bit of Leu

Microbial Protein

- **The goal of every ration should be to optimize the amount of microbial protein.**

Because producing more microbial protein entails adding more feed for an ever decreasing amount of microbial protein, maximizing microbial protein may not be economically viable.

RUP

The portion of true protein that escapes degradation by rumen microbes (RUP) is the second greatest source of AA for the cow.

Normally 25-35% of total AA

RUP

Item	Arg	His	Ile	Leu	Lys	Met	Phe	Thr	Trp	Val	EAA
Milk	3.3	2.8	5.7	9.9	7.9	3.0	5.0	4.1	1.4	6.6	49.7
R. Bact	5.1	2.0	5.7	8.1	7.9	2.6	5.1	5.8	-	6.2	49.8
R. Prot	3.5	1.5	5.5	6.7	8.2	1.7	4.7	4.4	-	5.2	42.7
DDG	4.3	2.7	3.7	11.7	2.8	2.0	4.9	3.7	0.8	4.9	41.3
Canola	6.4	2.9	4.2	6.8	5.9	2.1	4.2	4.5	1.5	5.4	43.7
SBM 48	7.3	2.6	4.5	7.6	6.1	1.3	5.1	3.9	1.3	4.7	44.5
Blood	4.3	5.9	1.1	12.3	8.7	1.2	6.8	4.6	1.4	8.2	54.3
Fish	5.8	2.7	4.0	7.1	7.3	2.7	3.9	4.1	2.2	4.8	44.6
Pork	6.7	2.0	2.8	5.8	5.1	1.4	3.3	3.1	0.7	4.0	34.7
Poultry	6.6	2.2	3.8	7.0	5.9	1.9	3.9	3.9	1.0	4.7	41.0

RUP

Are the AA of RUP the same as intact protein?

For most feeds, the answer is yes.

For animal protein meals, the answer may be different.

For poorly fermented silages, the answer may be different -

needs a significant amount of research

RUP

Do all AA in RUP have the same digestibility?

Answer is clearly NO. But every model uses 80% because that is global average

-does not do bad, but we can do better

Endogenous protein

General agreement that the rest of protein is endogenous protein

Scarf protein and digestive secretions

-really not “new” AA, as most are secreted and then absorbed

Endogenous protein

How big a contribution?

estimates from 1 to 15%

How long can this level be maintained?

Need a lot of research here!

AA Supply

The really good news is that models built on NRC, AminoCow and newer versions of CNCPS do a reasonably good job of predicting AA flow over a wide range of rations and management conditions.

Not perfect, but good

Flow	Overall	Grass	Alfalfa	Corn silage
MCP	None	None	AMT, NRC	NRC
RUP	None	None	None	None
Arg	AC, NRC	AM	AC, NRC	None
His	AC	None	AC	AC
Ile	NRC	AC, AMT	NRC	AC, AMT, NRC
Leu	All	All	None	NRC
Lys	AC, AMT, NRC	AC, NRC	AC, AMT, NRC	AC, NRC
Met	AC, NRC	None	None	AC, NRC
Phe	AC, AMT, NRC	AC, AMT	AMT, CPM	AC, AMT, NRC
Thr	All	AC, AMT, NRC	AMT, CPM	All
Val	AC, AMT, NRC	AC, CPM	AC, AMT,NRC	AC, AMT,NRC

Pacheco et al., 2012

Requirements

- This means we have a reasonably good idea about the amount of AA arriving at the small intestine.
- What we really do not know is the requirements, especially the requirements for lactation
  - -not so unusual, lactation requirements for all species are 'guestimates'

Requirements

How could this be so?

1. We know that the intestine uses AA for energy, especially branched chains (Ile, Leu and Val)

   -Is it required, variable, or luxury consumption?

Requirements

2. We know when a cow is in negative energy balance (transition, early lactation) up to 50% of glucose is from AA

-do we need to feed for this?

Variable	Mean Ratio	sd	Min	Max
Milk true protein yield, g/d	794	155	370	1,076
Metabolizable protein, g/d	1,794	485	747	3,619
Arg U:O	2.45	0.60	0.88	4.18
His U:O	1.08	0.25	0.46	1.80
Ile U:O	1.41	0.20	1.01	1.96
Leu U:O	1.31	0.24	0.98	2.37
Lys U:O	1.33	0.25	0.60	2.09
Met U:O	0.96	0.11	0.59	1.18
Phe U:O	1.07	0.08	0.82	1.29
Thr U:O	1.19	0.18	0.87	1.58
Val U:O	1.49	0.27	0.85	2.22
Mammary plasma flow L/d	14,160	2,784	9,384	23,976

After Lapierre et al., 2012

Requirements

3. We already know milk protein is 50% EAA. This indicates EAA must be between 70-85% of total milk protein.

-Does this indicate a requirement?

-Would the gland prefer to use EAA?

-Luxury consumption?

Requirements

Both Patton (2010) and Pacheco et al (2012) found that fully 1/3 of study were MP deficient when entered into the NRC model

-Suggests that NRC requirement is too high

-Is this because the AA composition of the protein is not accounted for?

Requirement, % MP

Item	NRC	AC	CPM	CNCPS
MP, g/d	2784	2047	2266	2759
Arg		3.81	6.00	6.05
His		3.03	1.94	1.88
Ile		5.42	5.30	4.68
Leu		9.77	8.16	7.47
Lys	7.2	8.21	5.78	5.44
Met	2.4	2.69	1.77	1.63
Phe		4.79	3.18	3.01
Thr		4.74	3.13	4.71
Trp		1.47	1.06	1.09
Val		6.30	5.87	5.29
%MP		50.23	42.19	41.25

3rd Lact. Hol, 1430 BWT, BCS =2.75, ADG =0.3 lb, 90 lb milk 3.10 MTP%

Requirement, g/d

Item	NRC	AC	CPM	CNCPS
Arg		78	136	167
His		57	44	52
Ile		111	120	129
Leu		200	185	206
Lys	200	168	131	150
Met	67	55	40	45
Phe		98	72	83
Thr		97	71	130
Trp		30	24	30
Val		129	133	146

Requirements

- We found that for milk protein % use of g/d EAA was as well correlated as AA%MP
  - (adjR^2 = 0.811 and 0.810, RMSE = 0.14 and 0.14, for g/d and AA%MP, respectively).
- For milk protein yield, use of g EAA/d was a better measure
  - (adjR^2 = 0.952 and 0.937, RMSE = 0.04 and 0.05 for g/d and AA%MP, respectively).

Requirements

Who is 'right'?

While they are surely all incorrect, none of them are wrong.

The authors have simply evaluated the available data differently.

None have been challenged like they should be!

Requirements

Because of the differences between lactation and growth, as well as the ability of the mammary gland to control blood flow and extraction %, **we may never have exact requirements.**

Rather we may have ranges for AA at a given production level.

Studies

Classic study of Schwab et al., 1992a,b

-Infusion of 4 L of AA in liquid

-Based on corn silage, grass silage and corn grain

-protein a mix of DDG and SBM

-10-day periods

-Looked at 4 stages of lactation to find Met and Lys requirements

-reasonably high microbial protein %

DIM	Item	12 DLM	30 Lys	12+ 30	400 Cas
28	Milk	82.3	87.6	88.0	88.0
	Prot,%	2.66	2.71	2.85	2.83
	Prot g/d	990^{b}	1086^{ab}	1136^{a}	1133^{a}
70	Milk	77.2	78.3	77.0	81.4
	Prot,%	2.72^{b}	2.81^{ab}	2.86^{a}	2.86^{a}
	Prot g/d	943^{b}	993^{ab}	995^{ab}	1054^{a}
153	Milk	63.4^{c}	64.5^{bc}	65.6^{b}	68.0^{a}
	Prot,%	2.88^{b}	2.87^{b}	2.97^{a}	3.00^{a}
	Prot g/d	824^{b}	836^{b}	880^{a}	920^{a}
210	Milk	46.4	46.0	46.6	45.8
	Prot,%	2.99^{b}	3.00^{b}	3.15^{a}	3.05^{a}
	Prot g/d	628	628	663	632

14% CP basal diet — Schwab et al., 1992a

DIM	Item	H_2O	10 DLM 10 Lys	10 DLM 20 Lys	10 DLM 30 Lys
28	Milk	69.7^{b}	70.8^{b}	76.3^{a}	78.1^{a}
	Prot,%	2.78	3.06	3.05	3.04
	Prot g/d	840^{b}	976^{ab}	1039^{ab}	1070^{a}
70	Milk	71.5	71.3	72.8	72.2
	Prot,%	2.85^{c}	2.92^{b}	2.99^{a}	2.96^{a}
	Prot g/d	917^{c}	935^{a}	978^{a}	961^{ab}
153	Milk	66.9	69.1	66.9	67.5
	Prot,%	3.02^{b}	3.09^{a}	3.15^{a}	3.16^{a}
	Prot g/d	899	953	946	962
210	Milk	50.6	45.5	48.6	48.6
	Prot,%	3.15^{b}	3.25^{ab}	3.29^{a}	3.30^{a}
	Prot g/d	721	669	733	729

14% CP basal diet — Schwab et al., 1992b

Studies

Benefield et al., 2009

-Fed 2 different RPMet products; 1 at 2 rates

-2-wk periods, data reported each week

-Based on corn silage, alfalfa hay, and corn

-Protein mixture of soybean meal and expeller soybean meal

Item	Week	Control	RPM6	RPM12	RPM12
Milk	1	84.5	81.0	79.6	81.4
	2	81.4	79.0	79.6	81.4
	Average	82.9	80.1	81.0	82.5
MTP,%	1	2.90[a]	3.02[b]	3.02[b]	2.98[b]
	2	2.97	2.99	3.03	3.04
	Average	2.94[a]	3.00[b]	3.03[b]	3.01[b]
MTP, g/d	1	1110	1110	1130	1110
	2	1100	1070	1100	1120
	Average	1100	1090	1110	1120

16.4% CP basal diet

Benefield et al., 2009

Studies

Broderick et al., 2008

Became apparent when there was lots of MP, there was no response to RPMet

-Wanted to look at RPMet with reduced protein

-Corn silage, alfalfa silage, HMSC based diets

-Protein mixture of WRS and SM

-periods of 4 wks

Exp1	Item	18.6 CP, 0 DLM	17.3 CP, 5 DLM	16.1 CP, 10 DLM	14.8 CP, 15 DLM
	Milk	87.3[b]	91.5[a]	91.5[a]	87.3[b]
	MTP, %	3.02	2.98	2.97	3.04
	MTP, g/d	1150[b]	1230[a]	1230[a]	1200[ab]
Exp2		**17.3 CP, 0 DLM**	**17.3 CP, 10 DLM**	**16.1 CP, 0 DLM**	**16.1 CP, 10 DLM**
	Milk	87.6	88.2	86.2	85.1
	MTP,%	3.07	3.09	3.07	3.06
	MTP, g/d	1210	1230	1190	1170

Broderick et al., 2008

Studies

Lee et al., 2012a
- -corn silage, alfalfa haylage, corn based
- -Protein mix WRSB and SBM
- -Period of 10 weeks
- -MP adequate diet, MP deficient diet, and MP deficient diet plus RPLys and RPMet

Item	Ad-MP	Def_MP	Def_MP + Lys +Met
Milk	79.6	76.1	74.8
MTP, %	3.04[a]	2.92[b]	2.95[ab]
MTP, kg	1190[a]	1120[b]	1120[b]
	15% CP	14% CP	14% CP

Studies

Lee et al., 2012b
- -Corn silage, alfalfa silage, corn grain base
- -Protein Mix, WRSB, canola meal, expeller soybean meal
- -12 weeks
- -MP adequate, MP Deficient, MPdef +Lys+Met, MPdef +Lys+Met+His

Item	Ad-MP	Def_MP	Def_MP + Lys +Met	Def_MP + Lys+ Met+ His
Milk	**85.4[a]**	**77.4[b]**	**81.2[ab]**	**84.7[a]**
MTP, %	**2.98**	**2.94**	**2.99**	**3.03**
MTP, kg	**1130[a]**	**1010[b]**	**1100[a]**	**1140[a]**
	15.7% CP	13.6% CP	13.6% CP	13.6% CP

Limiting Amino Acids

Since Rulquin and his co-workers, Schwab and his co-workers, Met is thought of as most likely to be limiting.

In a big meta-analysis, we proved that is more or less correct.

-Most studies with high MP and short time-still an effect

Limiting Amino Acids

Same people assumed Lys is second limiting

Robinson (2010) in meta-analysis

found no effect of added Lys;

we found no effect of Lys on Met response.

-High MP; short time

Limiting Amino Acids

- Lys (continued)
- Because of microbial protein synthesis, probably less likely to be limiting than His or perhaps others, but still important—especially in early lactation.

Limiting Amino Acids

Much speculation because of Leu effect on mTor, adding Leu should affect protein response.

-Has not been shown to date

-Suggest that trials be held for longer periods and with lower MP

As microbial protein becomes greater percent, more likely to be limiting

Limiting Amino Acids

Studies with other EAA (Ile, Phe, Thr, Trp and Val) have really not been looked at

-especially for the longer term

For the ruminant, any EAA can become limiting, (1) if MP is not high, (2) there is not a great amount of RUP, and (3) as the animal depends on greater percent of microbial protein.

Limiting Amino Acids

In summary, for what we know right now:

1. Met-because it is low in both microbes and in most RUP sources, is probably most limiting.

2. Other EAA are hard to be limiting if MP is high.

Limiting Amino Acids

3. If MP is reduced, then His probably becomes second limiting.

4. Lys appears to be 2nd or 3rd limiting in early lactation; after this it is pretty hard to find a deficiency.

Beyond that we really do not know.

Why reduce MP?

1. If MP is reduced, then get less N into the environment.
2. Protein is **EXPENSIVE**.
   -At today's prices that means we can lower costs from $0.25-$0.50 per day.
   -If we do not lose production (either milk or milk protein yield), it's a no brainer.

The Big Question:

In a practical sense, what do we do with all of this?

How should I begin to balance amino acids for dairy cattle?

Balancing for Amino Acids

1. Commit to balancing for AA!

   Understand that it is:
   (a) more than a Lys:Met ratio
   (b) more than Lys or Met as % MP
   (c) an on-going process –we do not have good requirements yet

Balancing for Amino Acids

2. Select a model and stick with it.

   As indicated, every model except old CPM is okay until we know more.

   Learn the assumptions and how to use the model.

   Make sure it has some evaluations.

Balancing for Amino Acids

3. Collect the information needed to make the model run:
   - A. Body weight
   - B. Know what to ask the feed laboratory to provide.
   - C. Do not assume the RUP and AA numbers for one model will work in another.

Balancing for Amino Acids

4. Measure the DMI for each group

We found the best model predicted with 3.5 lb of actual DMI only 60% of the time.

3.5 lb of DM is a lot of microbial protein

-Do you really want to feed 1 TMR to the whole herd and use AA balance?

Balancing for Amino Acids

5. Optimize for microbial protein.

For all the reasons we have talked about-

Balance NDF and fiber mat first

Balance NFC and RDP

Maximizing may be too expensive.

Balancing for Amino Acids

6. Meet projected deficits
   - A. MP by adding RUP
   - B. EAA by adding RPAA—if unavailable, then add best RUP source
   - C. Satisfy on the basis of grams

Cows do not eat ratios.

Balancing for Amino Acids

6. Meet projected deficits (continued)
   Balance the g for the model you are using.

   After you are comfortable, then you can fine tune it for what the cows are telling you.

Balancing for Amino Acids

7. If group is less than 16 DIM, add 12% more MP to cover most of the need for gluconeogenesis

   AC, NC already added, the rest need to be added

Balancing for Amino Acids

8. Believe in the cow.

   If the model says that the diet you are feeding lacks an AA, and the cow is producing that amount of milk and milk protein, the chances are the model is incorrect and not the cow.

   The chances are that it is the requirement and not the flow of AA to the duodenum.

Balancing for Amino Acids

9. Monitor the situation.
   - If the MP is lowered and RPAA is added:
   - If more RPAA is added:
   - If more MP is added:
   - Keep a close eye on production and keep fine tuning it until you have optimized the situation for the dairyman—both long and short term.

Balancing for Amino Acids

In our experience,

if your clients know DMI, if they have forages and byproducts of consistent quality, levels of 90-95 lb of milk per day on a whole herd basis can be maintained on 15.6-15.8% CP. Have seen a 15.2% for 8 months.

If not, protein will have to be raised.

The Challenge is Yours

Like other important advancements, the expertise in AA balance will come from the field.

This is your chance to really impact on your client's economic health and on the science of nutrition.

Thank you for your attention.

Any questions?