Balancing amino acids brings opportunities for maximising production

Over recent years tremendous efforts and research have been made to refine the protein requirements of dairy cows. Consequently, our growing understanding of cow requirements led to recognising two sets of protein requirements; rumen degradable protein (RDP), and rumen undegradable protein (RUP). Besides this, metabolically the cow has specific requirements for individual amino acids (AA) rather than metabolisable protein (MP) per se.

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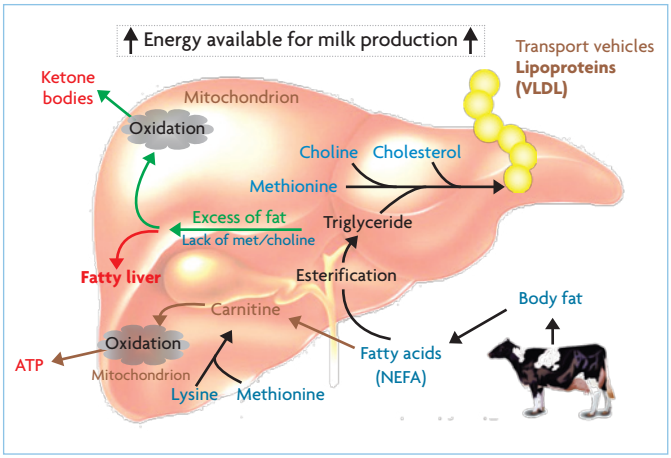


Fig. 2. Liver function diagram.

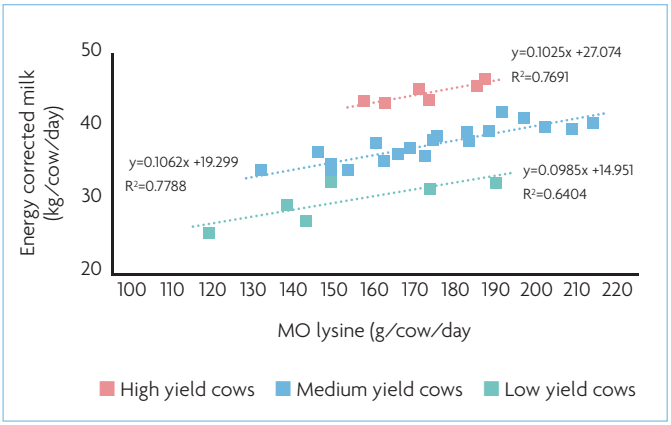
Amino acids are the building blocks of milk and body proteins and considered one of the most important nutrients in dairy cow nutrition. Many of these amino acids need to be supplemented in the diet, because they can not be synthesised enough to meet the requirements of producing cows. Therefore, these amino acids are known as essential AA. Inadequate supply of these essential AA can limit milk and milk protein yield; thus, they are referred to as limiting AA.

The essential AA that is present in MP is the smallest supply relative to cow's requirements and is referred to as limiting AA. Methionine (Met) and lysine (Lys) have been recognised as the first limiting AA, for lactating dairy cows under most feeding practices. This is fundamentally true because feed proteins have lower concentrations of Met and Lys when compared to their concentrations in milk and microbial protein (Table 1).

Intestinally available AA are derived from three sources: microbial protein, RUP, and endogenous protein. Collectively, these protein sources are called metabolisable protein. Therefore, dairy rations should be formulated to provide MP with an AA profile that is consistent with the AA requirements for maintenance, growth, lactation, and reproduction.

Rumen protected amino acids are the best way to provide the limiting amino acids. Even though these sources differ in the protection technology used (fat coating, pH sensitive coating, chemical protection or using analogs), we have to know the true bio-availability of methionine and lysine of all of these supplements and to choose the most metabolisable amino acids for the price.

Fig. 1. Relationship between the level of metabolisable lysine (MP lysine) and energy corrected milk (ECM) production at different levels of milk performance.



Benefits of balancing for amino acids

In mid-range crude protein diets in Europe it is not possible to meet methionine or lysine needs with the use of dietary feed ingredients, therefore the use of rumen protected methionine and lysine is needed.

It is remarkable that methionine and lysine work in concert; both amino acids are necessary in our diets for the best precise feeding to achieve the maximum production performance without overfeeding protein.

Balancing dairy rations for AA, rather than CP%, is the state-of-the-art approach when it comes to protein nutrition. Balancing dairy rations for AA allows for more precise feeding so that cows can achieve maximum production performance without overfeeding protein.

The benefits of balancing for AA are endless if dairy nutritionists and producers are willing to adopt the concept and apply it whenever possible. The improvement in milk production, reproduction as well as animal health will outweigh any additional cost.

Enhance productivity performance

Garthwaite et al. (1998) summarised the effect of supplementing rations with metabolisable Lys and Met. Results indicated an improvement of the milk performance by balancing the diets for Lys and Met. A very important insight was that the positive effect is much stronger by starting the feeding of rumen protected AA during the close up period.

The positive effect of Met on milk performance is well investigated in a lot of scientific and field studies. But what about Lys, the second limiting amino acid?

In Fig. 1, we summarise several studies showing the effect of rumen protected Lys on energy corrected milk (ECM) production. The studies were grouped according to the starting level of ECM before formulating the rations with rumen protected Lys. It was concluded that increasing the level of metabolisable Lys improves milk performance, that is independent of the production level. Rumen protected Lys increased ECM at both low and higher levels of the milk performance.

Utilisation efficiency of metabolisable protein

When one of the AA is limiting, then dairy cows will have an oversupply of all other AA. Moreover, when providing the missing block (the limiting AA) a new molecule of milk protein can be synthesised.

Continued on page 8

Item	Lysine	Methionine
Lean tissue	6.4	2.0
Milk	7.6	2.7
Rumen bacteria	7.9	2.6
Alfalfa Hay	5.0	1.5
Corn silage	2.5	1.5
Grass silage	3.3	1.2
Barley	3.6	1.7
Corn	2.8	2.1
Oats	4.2	2.9
Wheat	2.8	1.6
Corn distillers grains	2.2	1.8
Corn gluten meal	1.7	2.4
Canola meal	5.6	1.9
Cottonseed meal	4.1	1.6
Soybean meal	6.3	1.4
Sunflower meal	3.6	2.3
Fish meal	7.7	2.8

Table 1. A comparison of lysine and methionine content of body lean tissue, milk, and ruminal bacteria with that of some common feedstuffs expressed as % of crude protein (adapted and modified from Schwab and Ordway, 2001, and NRC, 2001).

Continued from page 7

Therefore, surplus of other amino acids will decrease, and the utilisation efficiency of MP will be improved. When dairy nutritionists rely mainly on the amount of MP available with no consideration for limiting AA, then in most cases, if not all, the actual milk yield will be lower than expected. This clearly indicates that, although the supply of total MP might be adequate, the balance of the available AA can be incorrect, alternatively limiting milk production.

Schwab et al. (2004) compared MP, Lys and Met supplies as predictors of milk production and milk protein yield. The results indicate that Met and Lys supplies are better predictors of both milk production and milk protein yield when compared to the supply of MP.

However, Lys supply has been demonstrated to be the best predictor of both milk production as well as milk protein yield with (r2 = 0.90). Therefore, adopting the concept of AA balance to supply the first two limiting AA will decrease the variation in predicting milk performance, improve the yield of milk and milk components, and decrease surplus in another AA.

It is widely accepted that the improvement in MP utilisation efficiency provides dairy nutritionists with an opportunity to formulate diets with lower CP content without compromising the yield of milk and milk components.

Decreasing the incidence of metabolic disorders

Balancing for methionine and lysine requirements improves the anti-oxidant animal capacity, better health status and immuno-metabolism.

When the first limiting AA is inadequately supplied in MP, there will be a surplus of all other AA which will not be utilised for milk and body protein synthesis.

Therefore, these AA will be catabolised, primarily in the liver, to produce ammonia, and then converted to urea.

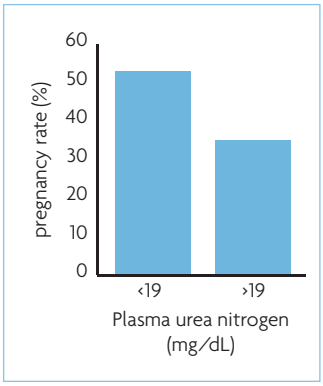
Excretion of excess ammonia in the form of urea is an energy consuming process. Therefore, when rations are balanced for Lys and Met, less energy will be required for the excretion of excess nitrogen into urea. Consequently, the preserved energy can be directed into more productive use, rather than wasted for the excretion of urea.

Obviously, this is of utmost importance in the early lactation period when cows are at negative energy balance, and sparing energy during the transition period is vital for lactating cows that ultimately help in minimising the incidence of metabolic disorders.

Additionally, Met plays a major role in the synthesis of apoprotein B, which is an essential component needed for the synthesis and secretion of very low-density lipoprotein (VLDL) that is responsible for exporting triglycerides from the liver to peripheral tissues. Met deficiency can impair the synthesis of apoprotein B, consequently decreasing the synthesis and secretion of VLDL, resulting in accumulation of triglycerides in the liver and the formation of ketone bodies.

Apart from participation in VLDL synthesis, Met and Lys have another important role in fat metabolism. They are both required for the synthesis of carnitine (Fig. 2), essential for the transport of NEFA from the cytosol into the mitochondria for subsequent fatty acid oxidation.

Fig. 3. A decrease in milk and plasma urea nitrogen (MUN and PUN) can improve conception rates (Butler et al. 1996).



Study	Days open	Services per conception
Ardalan et al., 2010	-27	-0.8
Nikkhah et al., 2013	-36	-0.3
Kemin internal publication	-33	-1.1
Kemin internal publication	-14	-0.4

Table 2. Effect of feeding rumen protected methionine and/or lysine on the reproductive parameters of lactating cows.

Parameter	Control	Kemin amino acid program	Difference
Milk protein (%)	3.29	3.40	+0.11
Milk fat (%)	3.41	3.57	+0.16
Casein (%)	2.48	2.59	+0.11
Casein/protein (%)	75.4	76.3	+0.90

Table 3. Dairy industry parameters for a ration for dairy cows balanced for Met and Lys compared with a control group.

Moreover, it is well known that carnitine plays additional important roles in protecting organisms from oxidative stress, promoting substrate oxidation in brown adipose tissue, and regulating energy partitioning in the body.

Improving dairy herd fertility

Feeding high levels of dietary CP, high RDP, or a diet with unbalanced AA, can cause an elevation in the concentrations of plasma urea nitrogen (PUN) and milk urea nitrogen (MUN).

Elevation of PUN and MUN has been associated with poor reproductive performance in early lactation dairy cows. The suggested mechanisms by which elevated urea nitrogen may affect fertility of dairy cows are:

- Ammonia or urea can affect the uterine environment and impair sperm, ova, or early embryonic development and survival.
- Exacerbation of the effects of negative energy balance during the transition period, due to the cost of urea excretion, and the accumulation of ammonia in the liver which impairs the conversion of propionate to glucose.
- Decreased plasma progesterone concentration.
- Increased secretion of PGF2α that interferes with embryo development and survival in dairy cows.

Overall, poor fertility in high producing dairy cows can be partially related to the combined effects of urea nitrogen on the uterine environment and progesterone level as well as the exacerbation of negative energy balance during postpartum period.

Researchers have demonstrated that conception rate decreases when PUN level is above 19mg/dL, or when MUN is more than 16mg/dL (Fig. 3). Therefore, it may be beneficial to dairy producers to monitor MUN in their herds to improve reproductive efficiency.

In general, to maximise dairy herd fertility, MUN is recommended to be maintained within the levels of 11 to 14mg/dL.

The levels of PUN and MUN can be decreased by balancing for the first two limiting AA, which improves MP efficiency, and decreases excretion of excess nitrogen as urea.

Many amino acids can have positive effects on physiological processes that are independent of their effects on the synthesis of proteins.

This has been termed 'functional effects' of amino acids. It was found out that Met and Lys are the 'functional amino acids' that have been linked to reproduction. One particularly interesting study used serum from lactating dairy cows in the media to grow head-fold stage rat embryos (9.5 days after breeding).

When embryos were grown in serum from dairy cows, embryonic development was abnormal. Supplementation of bovine serum with methionine alone was enough to produce normal development of the rat embryos in cow serum.

Better health and lower pregnancy losses by formulating rations based on amino acids should lead to a better reproduction performance at farm level (Table 2).

Increased casein content

The milk protein content is very important in cheese production. But the most important factor affecting the cheese yield (amount of cheese produced from 1kg of milk) is casein.

Casein content of milk protein is about 80%. Balancing the diets for amino acids improves milk protein content and automatically the cheese yield.

Additionally, there is strong evidence that well balanced diets can improve the casein content of milk protein. As a result, this has a double positive effect on cheese yield.

For example, the effect of amino acid balancing on milk protein and casein content was studied over a period of five months on a trial with 2x20 lactating Holstein Friesian (HF) cows between 93 and 244 days in milk. The results show a significant positive effect of rumen protected Lys and Met on milk fat, milk protein and for casein content (Table 3).

Special cheese sorts from small ruminants are very popular worldwide. In some regions, cheese production from goat and ewe milk is the biggest part of total cheese exports. Therefore, it is very important to know that using rumen protected AA can also improve cheese production (Table 4).

How to achieve the target formulation levels

When balancing dairy rations for AA, nutritionists are encouraged to consider the following recommendations for maximising milk components and MP utilisation.

- Diets should be formulated to maximise microbial protein synthesis, because microbial protein has an excellent profile of essential AA that matches the AA profile of milk protein.
- Maximising microbial protein can be achieved through synchronising the availability of readily fermentable carbohydrate with an adequate, but not excessive, quantity of RDP. Overfeeding RDP might exceed bacterial requirement, and ammonia produced in the rumen can decrease the flow of microbial protein to the small intestine.
- Balance the ration for the correct targeted levels for Lys and Met and maintain the recommended ratio of approximately 3:1 (depending on the ration formulation software).
- Provide a high quality high-Lys protein supplement to achieve the recommended Lys levels in MP. However, achieving the target recommended level of Lys is becoming feasible with the recent release of the rumen protected Lys products that can be used to partially compensate for the deficiency in Lys from feedstuffs without overfeeding RUP.
- Feed rumen protected Met in the amounts needed to achieve the targeted level in MP without oversupplying total MP. It is important for the dairy nutritionist to remember that rumen protected Lys and Met are not feed additives but are essential nutrients and should be used accordingly in ration formulation to meet the optimal Lys and Met levels in MP.

As you see, balancing diets for amino acids is not that simple. Therefore, along with the choice of the most high-quality product, the choice of an experienced advisor is also important.

This person/company should be able to provide constant support and act according to constantly changing market situations. Kemin's Amino Acid Program is supported by data-driven researches using sophisticated models that are validated in a three-step process: step one – in the laboratory; step two – in the animal and step three – in the dairy farm and industry.

Table 4. The dairy industry parameters for a ration for goats and ewes balanced for Met and Lys compared with a control group.

Parameter	Species	Milk protein (% points)	Casein (% points)
Kemin internal publication	Goat	+0.2	+0.3
Kemin internal publication	Ewe	+0.2-0.5	+0.1-0.5

Conclusions

In conclusion, balancing for AA rather than crude protein is the cutting-edge approach when it comes to protein nutrition.

Adopting the concept of balancing for AA can bring endless opportunities for maximising dairy herd profitability.

With the continuous increase in feed prices, and cost of milk production, diet reformulation with low crude protein content while balancing for AA, using rumen protected Met and Lys, can improve MP utilisation, and maximise dairy cow production.

One of the greatest benefits of balancing for AA is increasing milk and milk component yield with less RUP, at a similar or lower feed cost. The increase in milk yield is more common in early lactation cows and can be of great benefit if balancing for Lys and Met are already implemented in the close up period.

Additionally, balancing for the first two limiting AA will decrease MUN and overall nitrogen excretion, and will improve dairy cow health and reproduction, ■

References are available from the author on request