Concepts advance for amino acid balancing

Balancing for limiting amino acids affects a dairy cow's production parameters. Increasing use of ration formulation strategies that incorporate balancing for limiting amino acids is expected.

By **BRIAN SLOAN***

RENEWED interest exists in balancing dairy rations while also meeting the dietary requirements for the first two limiting amino acids: methionine and lysine.

When consideration during ration formulation is given to the metabolizable lysine and methionine concentrations within the ration's metabolizable protein (MP), more cost-effective rations can be formulated and better, more predictable milk performance achieved, both in volume and components.

Additional benefits exist. These include an increase in producer income over feed costs (IOFC) and relate to a role in preventing certain metabolic disorders, positively influencing energy balance and, hence, positively affecting reproductive performance and reducing the level of nitrogen excreted.

Microbial protein

Maximizing microbial protein contributions remains a first priority when balancing a ration for lysine and methionine. Sloan et al. (2000) showed that the efficiency of microbial protein synthesis improves when hydroxymethyl butanoic acid (HMB) is fed. Feeding HMB can ensure a maximum lysine content in the duodenal flows of protein and can create the opportunity to economize the ration's protein level.

HMB has a complex role in the rumen. Its precise mode of action remains to be validated, yet HMB has been intimated to have effects on rumen volatile fatty acid patterns, fiber digestion, microbial lipid synthesis and protozoa populations as well as the efficiency of microbial protein synthesis. Use of 0.10 HMB as a percent of dry matter intake appears to be optimal.

Optimal combination

The most attractive, practical strategy for feeding programs contains two steps. First, formulate for the limiting amino acids as this affects milk protein. Then, include HMB as it affects milk fat. In this way, milk volume and components can be supported.

On-farm strategies

On farm, three strategies can be applied to improve the nutrition of the dairy cow and the economic return to the dairy producer (Table):

- (1) If both the herd's milk volume and components are disappointing, maintain the current MP concentration in the ration, improve lysine and methionine to the maximum practical target levels and ensure a rumen-available HMB concentration of 0.10% to support milk yield and components. While feed costs may increase 20-40 cents per cow per day, the potential improvement in IOFC can be as much as 40-100 cents per cow per day.
- (2) The herd produces an adequate milk yield, but components are disappointing, and dietary protein inputs are high. Formulate to meet the target levels of lysine and methionine and incorporate HMB to allow MP (rumen undegradable protein [RUP]) levels in the ration to be decreased, improving the overall efficiency of the use of MP. Milk yield should be maintained and components supported for positive change.
- (3) Feed a "better" ration at the same price by moderately improving the levels of lysine and methionine by reformulating the ration. This provides positive support for the percent milk protein.

Results

When the ration is balanced for lysine and methionine, results consistently support a positive effect on milk protein percentage in the days following the ration change, with the full effects on milk fat percentage seen within a month (Garthwaite et al., 1998).

If the cows remain on a balanced

On-farm strategies to improve the nutrition of the dairy cow and economic return to the dairy producer

	Scenario 1: Improve volume and components	Scenario 2: Improve components	Scenario 3: Better rations, same cost
Milk yield, lb.	+4-8	+0-2	+0-1
Milk protein, %	+0.1-0.3	+0.1-0.3	< +0.1
Milk fat, %	+0.1-0.4	+0.1-0.4	< +0.1
Feed costs, cents per day	+20-40	+5-20	0
IOFC – cents per cow per day	+40-100	+20-60	+10-20

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amino acid ration program, the new level of milk protein percentage typically becomes more pronounced over time. Changes in milk protein percentage serve as the most readily apparent indicator of a successful change in ration formulation. Nevertheless, the economic advantage is determined primarily by the changes in milk protein and fat yield. Therefore, effects on milk volume are important, too.

The largest milk volume responses are observed in early lactation and are related to the degree of improvement in the lysine supply. Thus, depending on the proportion of early-lactation cows in the herd, an estimate can be made of the likely effect on milk volume from the change in ration formulation.

The next logical evolution toward more accurately satisfying the protein requirements of the dairy cow is formulating the ration for individual amino acids. When consideration is given to metabolizable lysine and methionine concentrations in MP and supplying HMB to the rumen, more cost-effective rations can be formulated, and more predictable milk performance (such as volume and components) can be achieved.

Benefits

Enriching the ration with limiting amino acids helps maximize milk protein synthesis as all absorbed amino acids can be used more efficiently. A proven strategy with poultry and swine, amino acid balancing is gaining acceptance and use by dairy nutritionists.

With dairy, the limiting amino acids are methionine and lysine. If corn is the only grain in the ration and some corn byproducts or brewers grains are fed, both lysine and methionine levels in metabolizable protein must be improved to see a response. If soybean meal is the principal protein source, performance often can be changed 30-70 g protein per day by increasing metabolizable methionine supplies 5-10 g per cow per day.

Milk performance. Garthwaite et al. (1998) summarized the published feeding trials concerning enriching rations in metabolizable lysine and methionine. For seven trials commencing immediately postcalving or within the first two or three weeks of lactation and continuing to at least 120 days in lactation, daily milk yield was affected by an average of 1.5 lb. of milk, milk protein yield by 80 g per day and milk protein percentage 0.16.

In five similar studies where the rations also were enriched with lysine and methionine in the closeup ration as well as for the first third of lactation, daily milk yield changed by 5 lb. of milk and 112 g of milk protein, and milk protein percent changed 0.09. In these five trials, daily milk fat yield also changed by 115 g and milk fat percent by 0.10.

When the principles of balancing rations for methionine and lysine were applied in the closeup rations, the maximum benefits were realized during lactation.

MP utilization. Research indicates that rations can be formulated at 16.5-17.5% crude protein when balanced for lysine and methionine without compromising milk yield and with significant support for milk components.

The dairy cow, in essence, has an oversupply of all other amino acids. When the missing link is provided, a new milk protein molecule can be synthesized, reducing the surplus of the other amino acids and improving the efficiency of MP use.

When MP is relied upon solely to estimate amino acid requirements, retrospective calculations show that actual milk yield falls short of MP allowable milk in 90% of situations (National Research Council [NRC], 2001).

In a recent analysis, Schwab (2004) showed that the overall efficiency of MP use for milk protein secretion is 0.64 compared to the NRC book value of 0.67. MP use was calculated to be better than 0.67 when balancing for methionine, and lysine was integrated into the ration formulation.

When MP alone is used to define amino acid supplies, individual limiting amino acids cannot be estimated, and therefore, milk performance likely will be less predictable.

Recently, Schwab et al. (2004) compared MP, lysine and methionine supplies as predictors of milk, volume and milk protein yield. MP supply did an adequate job ($r^2 = 0.65$) of predicting milk volume and a slightly better job of predicting milk protein yield ($r^2 = 0.74$). The latter would be expected to correlate more closely as both the inputs and outputs are in units of protein.

Compared to MP, methionine supply is a better predictor of both milk volume ($r^2 = 0.76$) and milk protein yield ($r^2 = 0.81$). However, lysine supply proved to be the best predictor of both milk volume and milk protein yield with r-squares of more than 0.90.

The analysis shows that the predictability of milk performance can be improved only by starting to pay attention to at least the first two limiting amino acids. By moving in this direction with formulations, the variation in predicting milk performance can decrease. By continuing to formulate rations uniquely on an MP basis with no consideration for metabolizable lysine and methionine, performance will be depressed and less predictable, and milk proteins and milk fats will not be optimized, reducing net returns from the sale of milk.

Feed efficiency. The efficiency of MP use benefits when rations are balanced for lysine and methionine, as does overall feed efficiency.

Hutjens (2005) proposed a measurement that can be calculated and used as an indicator of feed efficiency for evaluative purposes. Normally, this is expressed as pounds of 3.5% fat-corrected milk per pound of feed dry matter consumed. However, Hutjens proposed another indicator that corrects for protein as well as fat, which is more appropriate for consideration where the effects on milk protein yield also are expected to be important: 3.5% fat- and protein-corrected milk (lb.) = (12.82 x lb. fat) + (7.13 x lb. protein) + (0.323 x lb. milk).

For the seven early-lactation milk performance trials (Garthwaite et al., 1998), the average effect on feed efficiency was calculated to be 0.08 (1.93 versus 1.85).

Metabolic disorders. Less energy is needed to eliminate surplus amino acid nitrogen as urea when rations are balanced for lysine and methionine due to the more efficient use of MP. This allows energy to be put to more productive use and helps minimize metabolic disorders and delayed or impaired reproduction. High feed efficiency shouldn't occur at the expense of mobilizing energy reserves too rapidly as this encourages metabolic disorders and delayed or impaired reproduction.

In addition, the role of methionine in metabolism may further explain the advantages in feed efficiency and, in particular, energy status.

Methionine has been advocated as having a favorable role in hepatic metabolism through its capacity as a methyl donor. Methionine plays a key role in assuring the synthesis of aproprotein B, an essential component in the formation of the very low-density lipoprotein complex that is responsible for evacuating triglycerides from the liver to peripheral tissues.

Reproduction. Conventional

wisdom would indicate that any ration manipulation that can affect metabolic disorders and energy status of cows in early lactation also might have the potential to influence reproductive parameters (Santos et al., 2005).

Robert et al. (1996) observed a change in uterine involution (percent of animals whose uterus has regressed to normal size at 45 days postcalving). This was associated with a reduced number of inseminations needed per conception, but neither effect was significant.

They also measured milk progesterone levels every three days for the first 112 days of lactation to follow the cyclicity. Higher progesterone levels were noted pre-successful ovulation in the cows receiving a ration balanced for lysine and methionine than in the control cows. This is considered to potentiate a strong ovulation. Also during the five days after insemination, higher progesterone levels were noted. This often is regarded as a positive factor for embryo implantation.

Field trials (53 farms, 2,000 cows) conducted by Thiaucourt (1996) included feeding a ration formulated to be rich in lysine and methionine as a variable. It affected the timing to first insemination and calving interval by five days.

The other avenue through which ration amino acid balancing should be able to influence reproductive function is by lowering the ration's crude protein content. This supports desirable circulating levels of blood urea without a negative effect on milk performance.

Immune response. The role of methionine and lysine in immune function remains speculative in dairy cows. Only indirect evidence exists that balancing rations for lysine and methionine may affect the immune system. In chicks and in certain "stressed" feedlot steers, an effect does appear to exist.

Balancing for limiting amino acids affects milk performance, MP utilization, feed efficiency, metabolic disorders, reproduction and possibly immune response. Increasing use of ration formulation strategies that incorporate balancing for limiting amino acids is expected.

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