TECHNICAL BULLETIN
Report 06-4

VIGORTONE®
A Leader In
Animal Nutrition Since 1912
1-800-553-1712 www.vigortone.com

Balancing Ruminant Diets For Metabolizable Protein And Amino Acids

Part I: Understanding the Calculation of Metabolizable Protein and Amino Acids

The dairy industry has moved from balancing rations for crude protein (CP) to balancing for metabolizable protein (MP) and metabolizable amino acids (AAs). This article will be presented in three parts. Part 1 will explain how the quantity of MP and metabolizable AAs supplied to the ruminant is determined. Part 2 will explain how MP and metabolizable AA requirements are determined and Part 3 will explain how to balance a ration to meet these requirements.

Metabolizable protein is defined as the true protein that is absorbed in the cow's intestine. The two major sources of MP flowing from the rumen are Rumen Undegradable Protein (RUP), which is CP from feedstuffs that escapes rumen digestion, and Microbial Crude Protein (MCP), which is CP from microbial cells that grew in the rumen.

Calculating RUP

The 2001 NRC edition of Nutrient Requirements of Dairy Cattle divides feed protein into 3 fractions based on their reaction when placed into in situ bags and incubated in a rumen for a given length of time.

Fraction A. This is the portion of feed CP that immediately disappears from the porous in situ bags. It includes nonprotein nitrogen (NPN) compounds, such as urea and nitrates, and small true protein particles that are highly soluble, such as free amino acids and small peptides. This fraction is assumed to be 100 % Rumen Degradable Protein (RDP).

Fraction B. This fraction is the amount of CP that disappears from the in situ bags during the rumen incubation period after the initial disappearance of the A fraction. The B fraction represents the protein that has the potential to be degraded in the rumen, but due to passage out of the rumen before complete degradation, it partially ends up as RDP and partially as RUP. The proportion of the B fraction that becomes RDP vs. RUP depends on the combination of two factors: the rate of digestion (K_d) of the protein in the rumen and the rate of passage of feed particles from the rumen (K_p). A higher K_d means a higher proportion of the protein will be degraded in the rumen, while a higher K_p value means a lower proportion of the protein will be degraded in the rumen.

Fraction C. This is the proportion of CP that remains in the in situ bags after the designated time of ruminal incubation. The C fraction is considered to be 100% RUP.

The CPM-Dairy Ration Analyzer program that has evolved from the Cornell Net Carbohydrate and Protein System uses a slightly different means to partition protein fractions. It uses fractions A, B_1, B_2, B_3, and C. A is considered NPN, B_1 is rapidly degraded true proteins, B_2 is protein degraded at a moderate rate, B_3 is protein that is slowly degraded, and C is acid detergent insoluble crude protein (ADICP). The A fraction of the 2001 NRC publication is similar to the combined A and B_1 fractions of CPM. The B fraction of the 2001 NRC publication is similar to the B_2 fraction of CPM. The C fraction of the 2001 NRC publication is

(continued)

closely related to the B_3 plus C fractions of the CPM.

Table 1 (page 3) gives values for A, B, and C fractions of common feedstuffs, the K_d value of the B fraction, and examples of the RUP value based on two different K_p values when dry matter intake (DMI) is 2% of body weight (BW) or 4% of BW. It is evident from this table that both the proportion of CP in the B and C fractions, as well as the K_d, influence the RUP of a feedstuff.

It is interesting to note the difference in fractions A, B, and C between alfalfa hay and alfalfa haylage. Fermented forage has more of both the A and C fractions and less of the B fraction than dried forage. During the fermentation process, true proteins are broken down to smaller peptides or ammonia (creating more A fraction) or are bound to ADF due to heat damage (creating more C fraction). Processing methods can also affect protein fractions. For example, heat and pressure during the production of expeller soybean meal converts more of the A fraction to the B fraction and also dramatically reduces the K_d value compared to solvent extracted soybean meal (48%).

Calculating MP and metabolizable AAs from RUP

To determine the MP obtained from RUP, the amount of RUP derived from each ingredient in the diet must be multiplied by the intestinal digestibility of that ingredient's RUP. The amounts of intestinally digested RUP from all dietary sources are summed to obtain the total amount of MP from RUP. Table 2 (page 3) gives the intestinal digestibility of RUP of common feedstuffs. The metabolizable lysine or methionine from RUP sources is calculated by multiplying the MP obtained from each ingredient's RUP by its lysine or methionine content. For any feedstuff, if the AA composition of its metabolizable RUP is unknown, it is assumed to be similar to the AA composition of its CP.

Calculating MCP

The MCP production in the rumen from bacteria and protozoa cell growth is a function of the amount of nitrogen available from RDP and the amount of energy available from organic matter degraded in the rumen. The RDP is easily calculated as CP – RUP. The 2001 edition of Nutrient Requirements of Dairy Cattle uses TDN (discounted) as a measure of ruminally digested organic matter. Discounted TDN is TDN adjusted for the effect of DMI (or K_p) on carbohydrate digestion in the rumen. Depending on if RDP or if TDN is the limiting factor, MCP is calculated as the lesser value of 0.13 X TDN or 0.85 X RDP.

> Example: A ration containing 38.0 lb TDN (discounted) and 6.2 lb RDP would have enough energy to support the production of only 4.94 lb MCP (even though there is enough N to support the production of 5.27 lb MCP). [0.13 X 38.0 lb TDN = 4.94 lb MCP] and [0.85 X 6.2 lb RDP = 5.27 lb MCP]

Calculating MP and metabolizable AAs from MCP

Determination of MP obtained from MCP is based on the assumption that MCP is 80% true protein and 20% nucleic acids. Also, the true protein is 80% digestible in the intestine. Therefore MCP X 0.80 X 0.80 = metabolizable protein from MCP. The average lysine and methionine contents of microbial protein are 8.2% and 2.68%, respectively. These values are used to then calculate the amount of metabolizable lysine and methionine from metabolizable MCP.

Calculating total MP and metabolizable AAs

Finally, the total MP can be calculated by adding the amount of MP from RUP and from MCP. In the same way, total metabolizable lysine and methionine can be calculated by adding the amounts derived from RUP and from MCP.

(continued)

TABLE 1. Nitrogen Fractions of Common Ruminant Feedstuffs.

		N Fraction, % of CP			Kd (%/h)	RUP % of CP @ DMI of	
Feedstuff	**% CP**	**A**	**B**	**C**	**of B**	**2% BW**	**4% BW**
Alfalfa hay, immature	22.8	42.5	51.0	6.5	17.8	16.3	17.7
Alfalfa haylage, immature	23.2	61.6	29.1	9.3	13.1	16.5	17.9
Blood meal, ring dried	95.5	10.1	60.9	29.0	1.9	70.9	77.5
Corn, ground	9.4	23.9	72.5	3.6	4.9	37.0	47.3
Corn gluten feed	23.8	48.0	43.2	8.8	7.7	24.0	30.0
Corn DDGS	29.7	28.5	63.3	8.2	3.6	42.2	50.8
Corn gluten meal	65.0	3.9	90.9	5.2	2.3	63.8	74.6
Cottonseed, whole	23.5	45.4	46.7	7.9	15.7	17.7	22.9
Fish meal, menhaden	68.5	22.8	72.0	5.2	1.4	59.1	65.8
Soybeans, roasted	43.0	17.8	77.0	5.2	9.3	29.1	39.4
Soybean meal, 48%	53.8	15.0	84.4	0.6	7.5	30.8	42.6
Soybean meal, expeller	46.3	8.7	91.3	0.0	2.4	58.0	69.0

Source: Table 15-2a, Nutritional Requirements of Dairy Cattle 2001, NRC

TABLE 2. Digestibility of RUP plus Lysine and Methionine Composition of Proteins in Common Ruminant Feedstuffs

Feedstuff	% RUP Digested	% of CP Lys	% of CP Met
Alfalfa hay, immature	75.0	5.1	1.6
Alfalfa haylage, immature	70.0	4.5	1.4
Blood meal, ring dried	80.0	9.0	1.2
Corn, ground	90.0	2.8	2.1
Corn gluten feed	85.0	2.7	1.6
Corn DDGS	80.0	2.2	1.8
Corn gluten meal	92.0	1.7	2.4
Cottonseed, whole	80.0	4.4	1.7
Fish meal, menhaden	90.0	7.7	2.8
Soybeans, roasted	85.0	6.0	1.4
Soybean meal, 48%	93.0	6.3	1.4
Soybean meal, expeller	93.0	6.3	1.5

Source: Table 15-2a, Nutritional Requirements of Dairy Cattle 2001, NRC