FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

FRED D. BISPLINGHOFF, D.V.M.
Director Technical Services

7150 ESTERO BLVD. • APT. 906
FT. MYERS BEACH, FL 33931
AREA CODE 813 — 463-4744

This is a paper taken from FEEDSTUFFS, June 25, 1990 July 1990 No. 200

ENERGY AND PROTEIN RATIOS IMPORTANT FOR LACTATION

DR. PAUL CHANDLER
President
CHANDLER & ASSOCIATES

In the feeding of lactating dairy cattle, energy-protein ratios are somewhat ignored even though they are of primary consideration in the feeding of swine and poultry. These ratios are of primary importance in dairy cattle, however, and can have very useful applications where group feeding is carried out. The ratio is not constant over a lactation curve because of the dominant influence of nutrient requirement for milk synthesis, but body weight within specific production groups has little influence because of the magnitude of production requirements relative to maintenance.

Energy is the driving force for production. Protein needs become known after the energy status is determined. Excessive protein beyond the amount necessary to supply the amino acids needed at the metabolic rate established from energy intake is wasteful economically and of likely metabolic harm.

The condition is complicated further because of the supply of nutrients from metabolic reserves and the required need to restore those reserves at a later point. Metabolic reserves, whether measured as body weight or change in body condition score, are much stronger related to energy supply/need than to protein.

Another important point for consideration is the diet dry matter components. The major supply of metabolizable protein originates from the rumen in the form of microbial protein. The production of this pool of metabolizable protein is from rumen fermentable carbohydrates. Dietary components that supply energy for the cow, yet are non-rumen fermentable (fats), can result in a significant reduction of microbial protein relative to total energy intake. This happens even if there is no detrimental effect of the fat on the ruminal fermentation. In the presence of this event the difference becomes even greater.

The primary purpose of this bottom line note is to direct emphasis to the protein-energy concept and to illustrate some of the major factors causing the ratio to vary. The background material utilized is the NRC Update 1989 and some personal communication with other investigators.

Basic Energy-Protein Rations

Energy and protein requirements for maintenance, production and body weight changes in lactation were taken from Table 6-3 of NRC. These numbers are tabulated in Table 1.

It is apparent from Table 1 that the ratio of energy to protein is not a constant. The requirement for protein to energy is highest for the milk requirement and lowest for maintenance. The ratio relative to loss or gain in body tissue is intermediate between maintenance and production. As production increases, the demand for energy relative to protein will approach the ratio of milk. Live weight loss will narrow the ratio further since the energy supply relative to production need is greater than the protein supply.

Cows in early lactation are going to lose body condition scores or body weight. It is understood that condition scores are much better indicators of this condition than body weight. Based on changes in body weight as illustrated in NRC, a cow that freshens at a relative weight of 100, could drop to 93 by 60 days in milk and increase to 107 by lactation end. For a typical 1,400 lb. cow, this can amount to a weight loss in excess of 1.5 lb. per day during the first 60 days of lactation, with a recovery of 0.75-0.80 lb. per day for the remaining lactation period.

Table 2, computed from NRC Table 6-3 presents energy protein relationships across varying productions and body weights for cows showing weight loss, at equilibrium, and weight gain.

As illustrated in Table 2, energy-to-protein ratios become fairly constant at high productions. The ratio is more variable at lower production since the maintenance requirement begins to approach 50% of the total nutrient requirement. Body weight does not significantly alter the ratio unless the lower weights are from first lactation cows that must be provided nutrient supplies for growth.

The above ratios have been found very useful in diet formulation for larger herds where feeding of relative homogenous groups is possible. The proper energy-to-protein ratio is selected and the diet is offered in a free-choice manner. Regardless of the feed intake, protein will be present in the amounts relative to the production demands of the cow.

The main advantage of diet formulation on an energy-protein ratio is to assure proper protein relative to energy but yet avoid the wasteful and possible harmful overfeeding of protein. In many herd situations because of ingredient supply and quality, it is not possible to achieve the energy demands that are desired, yet protein needs can be satisfied very easily. Use of the ratio technique avoids the overfeeding of protein relative to energy.

Currently, emphasis is being directed toward a protein system based on rumen degradable and undegradable system. This system is designed to more accurately supply the protein to support rumen fermentation and then satisfy the post-ruminal needs. The energy-protein ratios were evaluated from the computer model supplied with the NRC and presented in Table 3.

Energy requirements relative to intake protein as described in the degradable/undegradable protein system are significantly higher than those observed in Table 2, which were produced from the total crude protein requirement. The trends, according to production and physiological conditions, however, are the same. One would assume that the degradable intake protein would relate consistently to energy since this need is for support of rumen fermentation. As noted in Table 3, the ratio varies from 7.55 to 7.84 with relative low standard deviation.

Fat As A Component Of Dry Matter

The models utilized for the derivation of the NRC feeding guides are based on a dry matter containing approximately 3% fat. Fat, even though an excellent energy source for the tissues of the cow, is a non-fermentable source for the rumen system. In most cases, when fat is introduced into the ration, either from high fat containing ingredients such as whole cottonseed or special additions like tallow and rumen-protected fat sources, highly fermentable carbohydrates are replaced. Thus, the rumen system does not benefit from the extra energy derived from the fat and may, in fact, have less energy because of the substitution of fat sources for fermentable carbohydrate.

Daily bacterial and protozoal crude protein (BCP) production in grams is calculated from daily NEL intakes in megacalories as follows:

$$BCP = 6.25\ (-30.93 + 11.45\ NEL)$$

From this equation it is determined that 1 megacalorie of NEL yields 71.6 g of bacterial crude protein. For diets that are beyond 3% fat, adjustments must be made in the feeding rate of bypass protein (UIP) to compensate for the unobtained BCP that is expected from the resulting NEL. At typical feed intakes of high-producing cows, it is estimated that an extra 100 g of UIP must be provided for each percentage unit of fat above 3%.

This consideration causes in the ratio of UIP/IP to vary, depending on the fat content of the dry matter. For conventional rations with fat at 3% of the dry matter a UIP/IP of 36-40% may be adequate. In rations with fat above 6% the UIP/IP will be above 40%.

The Bottom Line:

Energy to protein ratios are important considerations in the formulation of diets for lactating cows. The ratio is not a constant, but varies primarily with milk production. Physiological status (losing or gaining body condition) alters the ratio and must be considered in diet formulation for the early lactating cow.

The primary benefit of the energy-to-protein ratio is allocation of protein needs directly in line with energy status. This can be very useful, especially in those situations where full energy needs are not obtained because of limitations in supply or quality of feed ingredients.

Special considerations must be given to diets containing more than 3% fat with respect to protein in the undegradable form.

REFERENCES

(1) Nutrient requirement of Dairy Cattle. Update 1989. National Academy Press, Washington, D.C. 1988.

(2) Sweeny, T.F., Church & Dwight Co., Inc. Personal communication, June 1990.

(3) Ferguson, J. D., Cornell University, Personal communication, May 1990.

TABLE 1. Nutrient requirements

Body wt. (lb.)	Energy NEl (MCal)	Energy TDN (lb.)	Total crude protein (lb.)	NEl /CP	TDN/CP
			Maintenance		
1,210	9.09	8.752	0.851	10.68	10.28
1,320	9.70	9.348	0.895	10.84	10.44
1,430	10.30	9.943	0.944	10.91	10.53
			Production — Nutrients for 4% milk		
Milk (lb.)					
1	0.336	0.322	0.09		
40	13.426	12.880	3.60		
60	20.139	19.320	5.40	3.73	3.58
80	26.853	25.760	7.20		
100	33.566	32.200	9.00		
120	40.279	38.840	10.80		
			Daily live weight change		
Change (lb.)					
Loss					
- 0.5	1.118	1.085	0.16		
- 1.0	2.232	2.170	0.32	6.98	6.78
- 1.5	3.346	3.255	0.48		
Gain					
0.5	1.161	1.130	0.16		
1.0	2.322	2.260	0.32	7.26	7.06
1.5	3.483	3.390	0.48		

TABLE 2. Protein-energy ratios for lactating cows

Physiological condition	NEl /CP	TDN/CP
High milk (1.41-1.66 lb. loss)	4.24 ± 0.09*	4.09 ± 0.09
High milk (equilibrium zero loss)	4.38 ± 0.11	4.23 ± 0.11
High milk (0.67-0.78 lb. gain)	4.51 ± 0.10	4.35 ± 0.0
Low milk (0.67-0.78 lb. gain)	5.03 ± 0.24	4.86 ± 0.23

*Standard deviation

TABLE 3. Energy-to-protein ratios using degradable and undegradable protein

Physiological condition	NEl /IP	TDN/IP	NEl /DIP	Milk/UIP
High milk (1.04-1.69 lb. loss)	4.66 ± 0.11	4.49 ± 0.11	7.63 ± 0.05	29.71 ± 0.45
High milk (equilibrium 0 loss)	4.73 ± 0.08	4.55 ± 0.08	7.56 ± 0.06	29.14 ± 0.49
High milk (0.66-0.78 lb. gain)	4.78 ± 0.05	4.60 ± 0.05	7.55 ± 0.05	28.15 ± 0.67
Low milk (0.66-0.78 lb. gain)	4.90 ± 0.07	4.76 ± 0.08	7.84 ± 0.12	23.09 ± 1.83

IP = Intake protein; DIP = degradable intake protein; VIP = undegradable intake protein