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ENERGY, PROTEIN AND AMINO ACID REQUIREMENTS FOR GROWTH OF YOUNG HORSES

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Energy, protein and amino acid intake have the greatest impact on the growth and development of growing horses. Somehow we all know that this statement is true but we seem to push it to the back of our minds and focus on minerals and vitamins, the catalysts for quality development. In fact, if you read the popular magazines one gets the impression that energy and protein are the causes of all of the developmental problems in our young animals. Let's see if we can put energy and protein in their proper place in our feeding programs.

Energy and protein, and consequently amino acid, requirements for the young horse are a function of the size of the animal (maintenance needs) and the rate at which the animal is growing. Conversely, the rate at which an animal grows is a function of how well we meet his energy and protein needs. If you want to maximize the growth rate of the animal you must meet the animal's energy and protein needs. If you want to restrict the growth rate of the animal you restrict the energy or the protein intake.

Energy Requirements

Energy is required for all body functions. But energy is not a chemical that one can analyze for but the result of the metabolic processing of substrates including glucose, fatty acids (both long chain and short chain) and the carbon chains of proteins not required for other functions. There are two procedures for determining the energy requirements of a growing animal, the factorial approach and the feeding trial. The factorial approach involves the determination of the energy needs of the animal for maintenance and adding the energy required for growth. The NRC (1989) committee found that the data in the literature revealed that the daily digestible energy requirement for maintenance of mature horses was: DE (Mcal) = 1.4 + .03 Bw_{kg}. Since there were no direct measurements of the maintenance needs of growing horses it was assumed that the relationship was constant regardless of age. Thus a foal weighing 300 kg has a DE requirement of: DE (Mcal) = 1.4 + .03(300) = 10.4 Mcal/day. His growth requirement, which is added to the maintenance requirement, is based on tissue energy deposition and efficiency of the conversion of dietary energy to tissue energy. Tissue energy deposition is represented by the equation: DE (Mcal) = $(4.81 + 1.17X - 0.023X^2)(ADG)$ where X = age in months and ADG is average daily gain in kg. Thus the equation for daily digestible energy requirement for the growing horse is: DE (Mcal) = $(1.4 + 0.03\ Bw_{kg}) + (4.81 + 1.17X - 0.023X^2)(ADG_{kg})$. The proof, of course, is in how

the animals respond to the calculated energy requirement intake. We will look at that a little later in the presentation.

Protein Requirements

Protein requirements of the growing foal are a function of the amino acid requirements of the foal, the amino acid content of the feed ingredients and the digestibility of those amino acids. The protein concentration required in the diet is a function of how well the available amino acid content of the diet matches the amino acid needs of the animal. Since the requirement of the animal can be divided into both a maintenance and a growth component, and since both energy and protein restriction will reduce growth of the animal (Ott et al., 1986), a constant relationship exists between energy and protein needs. This relationship is represented by the following: CP (g/day) for weanlings = 50 g/Mcal DE, CP (g/day) for yearlings = 45 g/Mcal DE. These relationships exist only if the protein meets the amino acid needs of the animal and may be in excess of the animal's needs if the diet meets the amino acid needs with less protein.

Amino Acid Requirements

Most of the data on the amino acid requirements of the growing horse have been feeding trials that compare the growth of young horses on diets providing various concentrations of amino acids (Breuer and Golden, 1971; Hintz et al., 1971; Potter and Huchton, 1975; Ott et al., 1981). This work started back in the late 1960s and has continued into the 1990s. Lysine was documented to be the first limiting amino acid in most natural horse feeding programs, especially grass-based programs. This is because grasses and cereal grains tend to be quite low in lysine, requiring that the diet be supplemented with a more concentrated source of this amino acid. Soybean meal is the most likely source of higher lysine protein for horse feeds but animal protein products and a combination of other plant sources and lysine may also be used. There is general agreement that lysine is the first limiting amino acid in most equine diets; however, there is less evidence regarding the second limiting amino acid. Methionine, tryptophan and threonine are all candidates as the second limiting amino acid in growing horses because they are limiting in other species. The data on methionine supplementation for growing horses are mixed. Some experiments show a growth response to methionine supplementation, some show a negative effect and some no response at all (Borton et al., 1973; Meakim, 1979). Tryptophan is generally higher in horse feeds than in diets for other nonruminant animals so it is not likely to be limiting. Threonine may very well be the second limiting amino acid in grass-based feeding programs for horses.

The addition of 0.1% threonine to a 10.5% protein concentrate supplemented with 0.2% lysine gave a small but consistent response over the lysine response when fed with coastal bermudagrass hay (Table 1, Graham et al., 1994). This provides evidence that at least for grass-based programs, threonine is the second limiting amino acid for the growing horse.

Table 1. Influence of lysine and threonine supplementation on growth of yearling horses.

	Concentrate[1]		
	10.5% CP	10.5% CP + 0.2% lys	10.5% CP +0.2% lys +0.1% thr
Av. daily gain, kg	0.57	0.64	0.67
Heart girth gain, cm	9.7	10.1	11.3
Withers height gain, cm	5.0	5.1	4.8
Hip height gain, cm	4.6	5.0	4.8

[1]Fed with coastal bermudagrass hay

Growth Rates of Young Horses

The growth rate of the foal at any point in time is the function of the age of the animal, his genetic potential for growth, his previous growth history and the nutrients available at that point in time. For example, a Thoroughbred foal with the genetic potential to weigh 1000 lb at 14 months of age may get there by several different routes. The most efficient program, and the one least likely to cause development problems, is the program that results in the nice smooth growth curve that is typical of most texts and would represent the result of plotting the growth of a large number of foals. However, in real life this nice smooth curve does not represent the way most foals grow, although it certainly is an excellent goal for which to strive. A number of factors influence the growth rates of foals. Availability of adequate nutrients is important to maximizing, or at least optimizing, growth. The required nutrients change as the animal grows and the growth rate changes. The transition from suckling to weanling is a problem for some foals and they will sometimes only maintain themselves or will actually lose weight during this transition. Others will experience various health problems that will slow their development at some point during their growth phase. The key to minimizing the variability in the animals is to provide an optimal quantity of nutrients for each phase of the growth cycle. This requires that each animal be individually fed a concentrate balanced to be fed with the selected forage.

Meeting the Energy Requirements of the Growing Foal

The daily energy requirements of the foal can only be satisfied by providing the foal with a diet of suitable energy density that will allow the animal to consume enough energy to meet his needs. Yearlings restricted to forage will usually be able to consume enough energy to provide for the maintenance needs of the animal and support some growth. However, seldom will the animal be able to consume

enough energy to support a growth rate compatible with the animal's genetic potential (Roquette et al., 1985; Hansen et al., 1987; Webb et al., 1989). The concentrate (grain ration) therefore becomes a key component in providing adequate energy. With a typical grain concentrate providing 1.4 Mcal/lb (3.08 Mcal/kg) and a forage providing 0.82 Mcal/lb (1.80 Mcal/kg), as fed, the ratio of concentrate to forage can be used to optimize energy intake while controlling the energy density of the diet to minimize digestive problems. The NRC (1989) recommended energy intake of growing foals can usually be met with a concentrate to forage ratio of about 70:30 for weanlings and 60:40 for yearlings. Our data varied from these recommendations somewhat in that our weanlings averaged 62:38 (Table 2) and the yearlings averaged 64:36 (Table 3). Since horses of this age will consume about 2.4 to 2.6 lb/100 lb BW of as fed feed daily, this would mean that a 600 lb weanling would consume 9.0 to 9.6 lb of concentrate (60 - 64%) and 5.4 to 6.0 lb of hay (36 - 40%) daily. This is compatible with the generally accepted principle that horses should consume at least 1.0% of their BW in forage daily to maintain good digestive function. Some variation around this ideal ratio is acceptable and may even be expected but care should be exercised not to let it vary too heavily toward the concentrate.

Table 2. Daily dry matter intake by weanling foals[1].

	Mean ± SE	Range
Concentrate, %[2]	61.9 ± 0.3	60 - 63
Hay, %[3]	38.1 ± 0.3	37 - 40
Concentrate DM, %BW	1.45 ± 0.01	1.38 - 1.52
Hay DM, %BW	0.89 ± 0.01	0.84 - 0.97
Total DM, % BW	2.34 + 0.02	2.24 - 2.44

[1] 86 weanlings, ave. wt. 252 ± 4 kg
[2] Concentrate fed to appetite for 1.5 hr twice daily
[3] Hay was fed at 1.0% BW

Table 3. Daily dry matter intake of yearlings[1].

	Mean ± SE	Range
Concentrate, %[2]	63.6 ± 0.5	58 - 69
Hay, %[3]	36.4 ± 0.5	31 - 42
Concentrate DM, % BW	1.52 ± 0.02	1.33 - 1.82
Hay DM, % BW	0.85 ± 0.02	0.75 - 1.00
Total DM, % BW	2.37 ± 0.03	2.16 - 2.65

[1] 230 head, ave. wt. 355 ± 6 kg
[2] Concentrate was fed to appetite for 1.5 hr twice daily
[3] Hay was fed at 1.0% BW/day

Based on our data (Table 4), the energy intake of a 252 kg weanling gaining 0.80 kg/d and consuming 1.45% BW of DM from the concentrate and 0.89% BW DM from forage would be 16.5 Mcal/d. This is less than the 17.80 Mcal DE the NRC (1989) indicates this size foal would require when gaining 0.80 kg/d. Based on our data (Table 5), the energy intake of a 355 kg yearling gaining 0.57 kg/d and consuming 1.52% BW of DM from the concentrate and 0.85% BW of DM from forage would be 23.79 Mcal/d. This is greater than the NRC (1989) indicates this size yearling gaining 0.57 kg/d requires. These differences may be well within the expected variation that exists between animals and feeding programs or they may indicate that we need to revisit the energy requirements of growing horses to refine the recommendations.

Table 4. Daily energy intake by 252 kg weanling (6 mo. of age) gaining 0.80 kg/day.

252 kg x 0.0145 = 3.65 kg DM intake x 3.30 Mcal/kg =	12.06 Mcal
252 kg x 0.0089 = 2.24 kg DM intake x 1.98 Mcal/kg =	4.44 Mcal
	16.50 Mcal
NRC (1989)	
252 kg weanling gaining 0.80 kg/day requires	17.80 Mcal/d

Table 5. Daily energy intake by 355 kg yearling (13 mo. of age) gaining 0.57 kg/day.

355 kg x 0.0152 = 5.40 kg DM intake x 3.30 Mcal/kg =	17.82 Mcal
355 kg x 0.0085 = 3.02 kg DM intake x 1.98 Mcal/kg =	5.97 Mcal
	23.79 Mcal
NRC (1989)	
355 kg yearling gaining 0.57 kg/day requires	21.20 Mcal/d

Another consideration is the addition of fat to the concentrate to increase the energy density of the concentrate. The addition of 5% fat to the concentrate will increase the energy density of the concentrate by about 10%. This means that the animal can meet his energy needs with less concentrate. Our experience with this type of program (Table 6) is that it lowers the concentrate and subsequently the feed intake of the animal and decreases the blood insulin concentrations which may be advantageous in helping minimize bone development problems.

Table 6. Influence of fat addition to the concentrate on feed intake and growth of yearling horses.

	Concentrate	
	Basal	Basal + 5% fat
Concentrate intake, kg	5.74	5.38
Hay, kg	3.25	3.20
Total, kg	8.99	8.58
ADG, kg	0.61	0.59
Withers height gain, cm	2.25	2.76
Heart girth gain, cm	7.05	8.23
Body length gain, cm	5.95	6.31
Hip height gain, cm	4.20	3.88

Meeting the Protein and Amino Acid Needs of the Growing Foal

Based on our data (Table 7), the protein content of a concentrate can be reduced by 2 to 3% if 0.2% lysine is added to the concentrate and still support maximum growth response from the growing horses. Therefore, if you need a 15% concentrate to meet the needs of a yearling, a 12% protein concentrate with 0.2% added lysine will be comparable. It is important to provide the mineral and vitamin concentrations you would include in the 15% protein product because the foals will grow at the rate expected from the higher protein product. Although the data are much less convincing, it may also be possible to lower the protein even more, perhaps to 10.5 or 11.0%, by adding 0.1% supplemental threonine. The economics of that program probably favors the higher protein concentrate at this time. Lower threonine prices in the future may change that recommendation.

Table 7. Influence of lysine supplementation on growth of yearling horses[1].

	Concentrate[2]		
	14.5% CP	12.0% CP	12.0% CP + 0.2 % lysine
Initial weight, kg	340	330	330
Final weight, kg	441	417	431
Av. daily gain, kg	0.72	0.62	0.72
Withers height gain, cm	5.7	6.0	6.4
Heart girth gain, cm	14.8	12.2	16.3
Body length gain, cm	10.9	10.9	11.0
Feed/gain	16.5	17.9	15.0

[1] Ott et al., 1981

[2] Fed with coastal bermudagrass hay (1% BW)

Conclusions

Our current recommendations are shown in Table 8. At typical intake ratios between 70:30 and 60:40 concentrate to forage, these energy, protein and amino acid concentrations will provide appropriate nutrient intakes to support maximum growth in most weanlings and yearlings. When specified lysine concentrations can be provided using lower protein concentrations, similar growth responses can be expected. If the energy content of the concentrate is increased by the addition of fat, it is probably appropriate to increase the protein and/or lysine concentrations to compensate for the lower feed intake.

Table 8. Protein and lysine recommendations for concentrates for growing horses (as fed).

	Forage			
	Grass		Legume	
	Weanling	Yearling	Weanling	Yearling
Dig. Energy, Mcal/kg	3.00	3.00	3.00	3.00
C. Protein, %	18.0	15.0	15.0	12.0
Lysine, %	0.85	0.65	0.65	0.45

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