Kentucky Equine Research®
World Leaders In Equine Nutrition

Advances in Equine Nutrition

Volume IV

Edited by

J.D. Pagan

NUTRIENT REQUIREMENTS: APPLYING THE SCIENCE

JOE D. PAGAN
Kentucky Equine Research, Versailles, Kentucky

Introduction

Because the recommendations outlined in the current NRC *Nutrient Requirements of Horses* are based mostly on small controlled studies conducted with horses, ponies, and other species of livestock, it remains unclear how they should be applied to feeding horses under a range of management conditions. How should a feed manufacturer use NRC requirements to formulate horse feed and evaluate nutrient adequacy in rations? This paper will explore how well the NRC requirements fit the real world of horse feeding and will make suggestions about how they can best be utilized by the feed manufacturer.

Requirements or Recommendations?

The most fundamental question that we should ask about the NRC is what do the requirements represent? Are they the levels of nutrients that should be included in a horse's ration or are they the bare minimums required to prevent clinical disease? The 1989 NRC states that its nutrient requirements represent the minimum amounts needed to sustain normal health, production, and performance of horses. It cautions, however, that horses should be fed as individuals and that, when applying the recommendations, consideration should be given to factors such as: 1) digestive and metabolic differences between horses; 2) variation in production and performance capabilities of the animal and expectations of the owner; 3) health status of the animal; 4) variations in the nutrient availability in feed ingredients; 5) interrelationships among nutrients; 6) previous nutritional status of the horse; and 7) climatic and environmental conditions. In other words, the requirements probably shouldn't be strictly followed in real-life feeding situations where any or all of these factors come into play. Unfortunately, the 1989 NRC doesn't provide recommendations to adjust for any of these factors.

It is crucial that we differentiate between nutrient *requirements* and *recommendations* when evaluating the nutrient adequacy of a specific equine ration. Kronfeld (2001) stated that NRC nutrient *requirements* for companion animals are levels that are sufficient to prevent lesions or growth retardation in 50% of animals. Recognizing that the nutrient requirements for dogs and cats have little practical value,

the Association of American Feed Control Officials (AAFCO) created nutrient profiles for dogs and cats that were about 1.3 to 2 times the corresponding NRC values. In human nutrition, nutrient recommendations are expressed as RDAs (recommended daily allowances) that are two standard deviations above mean minimum requirements, thereby being sufficient for 98% of the population.

Kentucky Equine Research (KER) created its own set of nutrient "requirements" for horses shortly after the publication of the last NRC. These values should more correctly be termed recommendations rather than requirements because they are intended to account for many of the variables that affect nutrient adequacy, which were noted in the current NRC. They do not use a set multiplier of NRC requirements since many of the NRC values are already appropriate as practical recommendations under most management situations. Other KER recommendations are considerably higher than NRC values, while some are lower than the NRC requirement (Table 1). Even though KER's recommendations account for many variables encountered in feeding horses, they are too general to be used in every situation. Therefore, more specific recommendations are under development by KER for different breeds, disciplines, geographic regions, and pathological conditions.

Table 1. KER recommendations as multiples of NRC requirements.

Nutrient	*Class of Horse*				
	Maintenance	*Pregnancy*	*Lactation*	*Performance*	*Growth*
Protein	1.1	1.1	1.0	0.75-0.9	1.0
Energy	1.0	1.1	1.0	1.0	1.0
Macrominerals	1.3-2.1	1.1-1.9	1.1-2.3	0.8-1.9	1.3-3.1
Microminerals	1.0-2.3	1.4-2.6	1.4-2.7	1.0-2.4	1.4-2.6
Vitamins	0.9-2.3	0.9-1.8	0.9-2.3	1.0-2.4	0.9-3.6

The NRC provides equations to calculate only eight nutrient requirements (DE, CP, lysine, Ca, P, Mg, K, and vitamin A) using information about the horse's age, body weight, and average daily gain. Requirements for 13 other nutrients (nine minerals and four vitamins) are given as adequate concentrations in total rations for horses. No requirements are listed for seven additional B-complex vitamins or vitamin C, and surprisingly, no requirement is given for chloride except to say "chloride requirements are presumed to be adequate when the sodium requirements are met with sodium chloride." Many of these nutrients are important for different classes of horses and recommendations should be given for them even if concrete experimental data are not available to quantify a requirement. Additionally, there are several other feed constituents that affect the health and well-being of the horse. The 1989 NRC does not provide recommendations about the level of fiber required in the horse's ration other than to offer the rule of thumb that horses should be fed at least 1% of

their body weight per day of good-quality roughage or be given access to pasture for sufficient time to consume at least 1% of body weight as dry matter per day. The 1989 NRC discusses different sources of energy for the horse but does not provide recommendations for either safe or optimal levels of each source in the horse's ration. This is an area of prime importance for all classes of horses and should be a major focus of research in the future.

Acceptable Ranges

Only under very artificial experimental conditions will the intake of every nutrient exactly match the recommendation. Some nutrients will exceed recommendations by a large margin, while others might be slightly below. In truth, horses can tolerate and thrive on a range of nutrient intakes. That range, however, can vary tremendously depending on the nutrient and class of horse being fed. For example, potassium intakes are often much higher than required because forages are rich sources of potassium and high forage intakes are desirable for most horses. Energy intakes, on the other hand, must closely match the horse's requirement or the horse will gain or lose weight.

Kronfeld (2001) endorsed setting goals for intakes of energy and nutrients. These goals were not specified as single numbers or requirements, but rather as optimal or target ranges, with upper and lower limits as well as middle values (Figure 1).

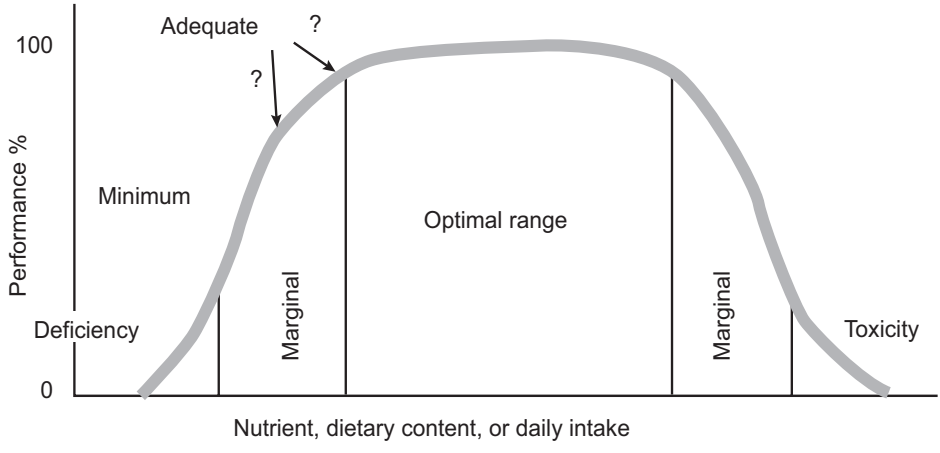

Figure 1. Optimal ranges for nutrient intakes.

KER has adopted this philosophy of assessing nutrient adequacy and has divided levels of nutrient intake into seven ranges as follows:

- *Deficient*: Nutrient intakes in this range will likely result in either the clinical expression of disease or a marked reduction in performance. Additional fortification is absolutely necessary.

- *Underfortified*: Nutrient intakes are marginal and may lead to deficiency symptoms or a drop in performance if the animal is stressed or if inhibitory substances are present in the ration. If practically feasible, the ration should be fortified with this nutrient.
- *Adequate (low range)*: The nutrient intake is below the target range, but under most circumstances should be adequate.
- *Target Range*: This range is very near the RDA for the nutrient, with slight variation to allow for uncertainties related to intake and ingredient composition.
- *Adequate (high range)*: Higher than recommended, but no undesirable effects other than possibly expense.
- *Overfortified*: Higher than required and may lead to problems related to interactions with other nutrients in the ration. If practical, nutrient intake should be reduced.
- *Excessive*: A level of intake that will likely result in toxicity symptoms or a drop in performance. Every effort should be made to reduce the level of intake of this nutrient.

Evaluating Rations

Table 2 and Figures 2 and 3 illustrate how KER recommendations and acceptable ranges can be used to evaluate a ration for a mare in the third trimester of pregnancy. This mare is in a desirable body condition and is gaining weight at an acceptable rate for late pregnancy. She is eating 5 kg of mixed orchard grass/alfalfa hay, 1.5 kg of oats, and 500 g of All-Phase balancer pellet per day. She is also allowed to graze a high-quality pasture during the day. Based on the caloric intake from hay, grain, and supplement, it is estimated that she is consuming 4 kg of pasture dry matter per day.

In Figure 2, daily intakes for each nutrient evaluated are expressed as a percentage of the KER recommendation. These nutrient intakes range from 90% of recommended for zinc (Zn) to 210% of the recommended intake for potassium (K). Are these nutrient intakes acceptable for a late pregnant mare? Figure 3 shows that all of the nutrients evaluated are well within either the target or acceptable ranges for pregnancy. Additionally, Ca:P ratio, % forage, and % dry matter fall within acceptable ranges. In conclusion, NRC requirements for horses are of little practical value for evaluating rations unless they are expressed as recommended daily allowances with acceptable ranges of nutrient intake. The next revision of the NRC will hopefully include more of this type of information.

Table 2. Nutrient intakes of a Thoroughbred mare during the third trimester of pregnancy.

Daily Nutrient Intake	*Fall Pasture*	*Mix Hay 20A:80G*	*Oats*	*All-Phase*	*Salt*	*RDA* (KER)*	*Total Nutrients*
Intake (kg/day)	4.0	5.0	1.5	0.5	0.03		11.03
DM (kg/day)	4.0	4.5	1.338	0.45	0.029	9.977	10.317
Protein (g/day)	640.0	500.0	177.0	125.0		1058.4	1442.0
Lysine (g/day)	22.4	19.0	5.9	7.5		37.0	54.8
DE (Mcal/day)	8.8	9.4	4.5	1.4		24.1	24.1
Ca (g/day)	22.0	26.3	1.2	15.0		53.8	64.5
P (g/day)	12.0	11.0	5.1	9.0		35.8	37.1
Mg (g/day)	8.0	10.0	2.1	2.0		13.4	22.1
Na (g/day)	0.4	0.5	0.8	3.4	12.0	15.0	17.0
Cl (g/day)	10.0	5.0	1.4	5.0	18.0	22.4	39.4
K (g/day)	68.0	66.2	6.0	6.5		69.8	146.7
Cu (mg/day)	48.0	45.0	9.0	75.0		171.0	177.0
Se (mg/day)	0.40	0.5	0.32	1.05		2.49	2.27
Zn (mg/day)	140.0	88.0	52.5	182.5		513.1	719.0
I (mg/day)	0.20	0.55	0.17	1.00		2.00	1.92
Mn (mg/day)	280.0	265.0	54.0	120.0		513.1	719.0
Vit. A (IU/day)	20000.0	30000.0	66.0	10000.0		49884.0	60066.0
Vit. D (IU/day)	2000.0	2750.0		1000.0		4988.0	5750.0
Vit. E (IU/day)	480.0	220.0	23.0	75.0		798.0	798.0

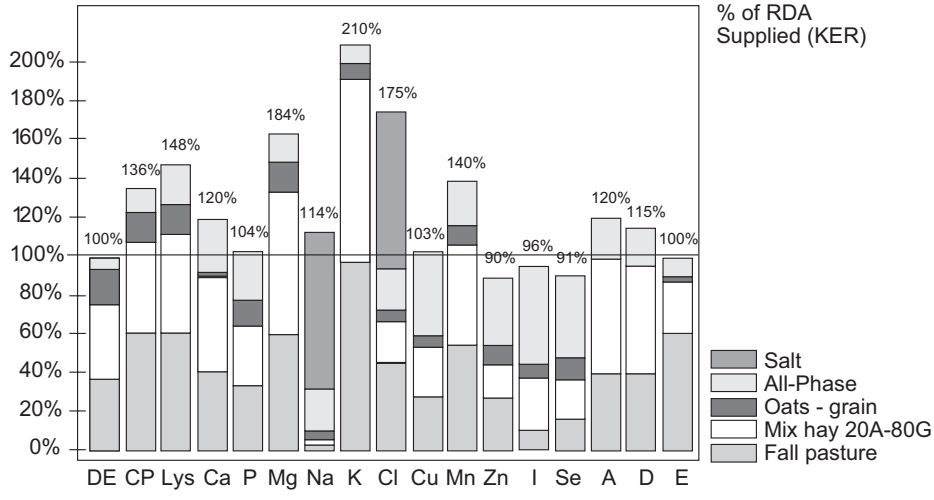

Figure 2. Daily intakes as a percentage of KER recommendations.

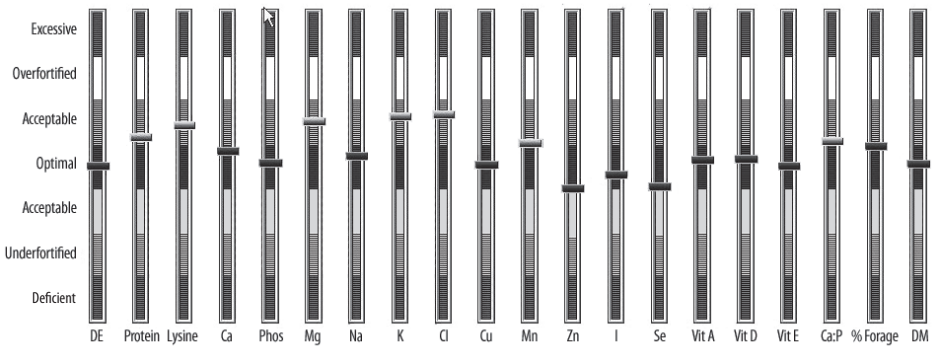

Figure 3. Daily intakes as they compare to acceptable ranges.

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