

A Review of the 1989 National Research
Council's Nutrient Requirements of the Horse

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A revision of the National Research Council (NRC) publication "Nutrient Requirements of the Horse" will be published in 1989. The previous edition was published in 1978. In the 11 years between publications a great amount of equine nutrition research was conducted in many parts of the world but particularly in the United States, France and Germany.

One of the major changes between the 1978 and 1989 publications was to provide equations for the calculations of energy protein, calcium, phosphorus, magnesium, potassium and vitamin A for all classes of horses. The equations are all shown in the publication, an IBM diskette with the equations is also provided with the publication. Thus values can be quickly calculated for any size horse rather than extrapolating from a table. Other changes are the inclusion of estimates for stallions and for heavy horses.

Energy

Several changes were made in the approach to defining energy requirements. In 1978 the maintenance **requirement** was defined as $DE \text{ (kcal/day)} = 155W^{0.75}$ where DE is digestible energy and W equals body weight of the horse in kg. The formula overestimated the requirements of ponies and Pagan and Hintz (1986) found no benefit from using the metabolic body size when studying horses weighing 125 to 860 kg. They reported that the energy requirement for such horses confined to metabolism stalls could be defined by the formula $DE \text{ (Mcal/day)} = 0.95 + 0.021W$ where W is weight of the horse in kg. The formula for zero body weight change plus normal activity of nonworking horses was calculated to be $DE \text{ (Mcal/day)} = 1.4 + 0.03W$. This equation is easy to use and seems to be reasonable for horses up to 600 kg. It overestimates the requirement of larger horses probably because of the reduced voluntary activity of those animals. Therefore the formula $DE \text{ (Mcal/day)} = 1.82 + 0.0383W - 0.000015W^2$ was used for the horses over 600 kg.

In the 1989 edition, the energy **requirements** for gestation are given for mares at 9, 10 and 11 months respectively rather than simply as during late gestation as reported in the 1978 edition. This refinement **was** made possible because of the studies of chemical composition of the fetus at various stages of gestation conducted by Meyer and Ahlswede (1976). The requirements were calculated by multiplying the DE maintenance requirements at 9th, 10th and 11th month by 1.11, 1.13 and 1.20 respectively based on the increases in energy deposition.

The estimates for lactating mares were made using the assumptions used in the 1978 edition. That is, that mares of light breeds produce milk equivalent to 3 percent of body weight/day during early lactation (1-12 weeks) and 2 percent of body weight during late lactation (13-24 weeks). Ponies were assumed to produce milk equivalent to 4 and 3 percent of body weight/day during early and late lactation respectively.

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The value for the conversion of DE into milk (792 kcal of DE/kg of milk) was the same as used in 1978.

Changes were made in the requirements for growth. Several recent studies indicated that the 1978 edition significantly underestimated the requirements for yearlings. The daily DE for growing horses was calculated using the equation: $DE(\text{Mcal/day}) = \text{Maintenance DE} + (4.81 + 1.17X - 0.023X^2)(\text{ADG})$ where ADG is the average daily gain in kg and X is the age in months. No conclusions were made as to optional growth rate but values for medium and rapid growth are given in the table to illustrate the effect of rate of growth on nutrient requirements.

The energy requirements for the working horse are a problem to calculate. The 1978 values were reasonable for horses at light work but greatly underestimated the requirements at hard work. Several different equations have been developed such as those of Anderson et al. (1983) and Pagan and Hintz but they have limitations for practical applications. It was decided requirements for light, medium and intense work could be estimated by increasing the requirements 25, 50 and 100 percent above maintenance respectively. Light work was considered to be horses used for pleasure classes, hacking, etc., medium work was horses used for roping, barrel racing, jumping; intense was considered race training, polo, etc.

Protein

The requirements for protein for maintenance and for working horses were calculated to be crude protein (g/day) = (40)(Mcal of DE/day). The requirement for pregnant mares is CP(g/day) = (44)(Mcal of DE/day). In the equation for lactating mares it was assumed milk contained 0.21 percent protein and the efficiency of conversion of CP to milk protein was 35.8%. The CP (g/day) for weanlings and yearlings was 50 and 45 per Mcal of DE/day. The calculations resulted in slightly higher values for pregnant mares and lactating mares but values for growing and maintenance animal similar to those of 1978.

Lysine requirements were estimated (g/day) as 50, 45 and 42.5 per Mcal of DE for weanlings, yearlings and 2 year olds respectively.

Minerals

Skeletal problems of foals are of great concern. Many minerals are involved in bone formation. Deficiencies of magnesium and manganese, excesses or deficiencies of iodine and zinc and excess of fluoride can cause bone problems. The two minerals that have received the most attention recently are calcium and copper.

Calcium has received a great deal of attention in both human and equine nutrition in recent years. The sales of calcium supplements for humans have greatly increased, spurred by advertisements stressing the importance of calcium for the prevention of several problems but in particular for prevention of osteoporosis. Although nutritionists in general applaud the increased interest in calcium, and in particular the stressing of the need of calcium by teenagers, not all nutritionists agree that increased calcium intakes by post-menopausal women will help prevent or treat osteoporosis and some feel that indiscriminate use of calcium supplements could cause kidney problems. Confusion- also exists about calcium nutrition of horses.

Calcium homeostasis is well defined in the horse. Two hormones - **parathormone** which is produced by the parathyroid gland and **calcitonin** which is produced by the thyroid gland - are involved.

Parathormone tries to prevent calcium levels in the blood from dropping too low by causing the release of calcium from bone into the blood. Chronic low intakes of calcium thus cause hyperparathyroidism and loss of calcium from bone. Calcitonin helps to prevent **calcium** levels in blood from getting too high by preventing calcium release from the bone. Thus chronic over feeding of calcium may cause hypercalcitoninism and dense, brittle bone.

Therefore, overfeeding or underfeeding of calcium can cause bone problems. There is however considerable difference in the opinions among authors as to what constitutes overfeeding and underfeeding. Knight et al. (1985) suggested that the NRC (1978) estimates for calcium were too low for prevention of DOD whereas Krook and Maylin (1988) concluded that "NRC (1978) has misinterpreted the literature" and that the NRC estimates are so excessive as to cause skeletal problems. The NRC (1989) examined all available data and made only minor changes in the estimates of calcium requirements. Although slightly different estimates of absorption coefficients were used, the equations (table 1) used in the preparation of the 1989 NRC edition gave values similar to the ones used in the 1978 NRC edition.

For example, in 1978 it was estimated that the 500 kg horse at maintenance required 23g of Ca and 14g of P daily. The 1989 estimates are 20 g of calcium and 14 g of phosphorus. In 1978 it was estimated that a month old foal with an estimated mature weight of 500 kg and gaining .8 kg per day would require 34 g of calcium and 25 g of phosphorus per day. In 1989, foals growing .65 or .85 kg per day were estimated to need 29 and 31 g of calcium respectively.

It was noted that exercise would increase Ca losses in sweat and would perhaps increase bone density and therefore increase Ca requirements. However, it was assumed that if the **Ca:calorie** ratio fed was adequate for maintenance, the increased energy intake needed for exercise would satisfy the calcium requirements if the **Ca:calorie** ratio was maintained.

TABLE 1 Equations for Calculation of Calcium Requirements

Estimation of calcium requirements (g/day)

Maintenance:	$Ca = 0.04 BW^a$
Pregnant mares: (9-11 months):	$Ca = (1.90)(Mcal \text{ of DE/day})$
Lactating mares: Foaling to 3 months 200 kg of BW	$Ca = (\text{maintenance Ca}) + [(0.04 BW \times 1.2)/0.5]^b$
400-900 kg of BW	$Ca = (\text{maintenance Ca}) + [(0.03 BW \times 1.2)/0.5]^b$

3 months to weaning
200 kg of BW

$$\text{Ca} = (\text{maintenance Ca}) + [((0.03 \text{ BW}) \times 0.8)/0.5]^b$$

400-900 kg of BW

$$\text{Ca} = (\text{maintenance Ca}) + [((0.02 \text{ BW}) \times 0.8)/0.5]^b$$

BW^a = body weight in kg

^bIt is assumed that pony mares produce an amount of milk equivalent to 4% of body weight in early lactation and 3% in late lactation and that mares 400 kg or greater produce an amount of milk equivalent to 3% of body weight in early lactation and 2% in late lactation. Milk was assumed to contain 1.2% Ca and 0.8% **Ca** in early and late lactation respectively. A 50% efficiency of utilization of dietary Ca was assumed.

Of course the amounts are adequate only when the calcium in the diet is efficiently utilized. Some plants such as vegetables and subtropical grasses may contain oxalic acid which binds calcium so that animals cannot use the calcium effectively. Spinach is a good example of a vegetable that contains oxalic acid. **Popeye** doesn't get his strength from the minerals in spinach. The oxalic acid makes the iron and calcium in spinach relatively unavailable. Of course most horses do not eat much spinach. But they do eat grass. Grasses that may contain excessive oxalic acid include buffalo, kikuyu, pangola, **setarea** including purple pigeon grass and rhodes (Jones et al., 1970; McKenzie et al., 1981; McKenzie, 1988).

Recent studies from Canada indicate that the calcium in cereal hays is not very efficiently used because of oxalate (**Cymbaluk** et al., 1986). The calcium in legumes such as alfalfa and in supplements such as limestone and dicalcium phosphate are usually effectively utilized by horses (**Hintz** et al., 1984).

Copper has received considerable attention since the reports by scientists at Ohio State University in 1985 of "on farm" studies (Knight et al., 1985; **Gabel** et al., 1987). The farms with horses with the most skeletal problems tended to feed lower levels of copper. There is no doubt that copper is required for normal bone development. Skeletal abnormalities due to copper deficiency have been reported in many species. Copper deficiency may cause decreased activity of the bone forming cells and therefore thin bone **cortices**. **Copper** is also required for normal activity of the enzyme lysyloxidase which is necessary for normal skeletal development.

There is, however, controversy over the amount of copper required to prevent skeletal problems in horses. The workers at Ohio State University recommend that weanlings be fed 150 to 175 mg of copper daily. This is equivalent to a dietary concentration of 30 ppm when conventional diets are used. Recent studies at OSU indicated that although foals fed a concentrate containing 15 ppm copper might appear to be clinically normal, such foals are likely to have more bone lesions than foals fed a concentrate containing 55 ppm copper at necropsy (Knight et al., 1987).

Other workers, however, reported that they found no skeletal problems in foals fed diets containing only 10 ppm copper. The differences between the studies might be due to several factors, such as genetic influences and interactions with other nutrients in the diet.

The 1989 NRC decided that the statistical evidence did not warrant increasing the copper requirement and therefore the 1989 NRC recommendation remains at 10 ppm copper on a dry matter basis.

I have visited farms that have a high incidence of DOD in their foals even though the foals have been fed levels of copper similar to those recommended by OSU. On the other hand, some farms that have increased the copper intake, although usually in addition to other dietary changes, have reported a decrease in the incidence of DOD.

Furthermore, there is no evidence that 30 ppm copper is harmful. Therefore, although I feel the copper story is far from being completely understood, I feel that the feeding of 30 ppm copper in the total diet is not unreasonable. However, that concentration of copper could be toxic to sheep. Therefore, horse feeds containing a high level of copper should not be given to sheep.

Further support for copper supplementation is suggested by the work of Auer et al. (1988) who recently reported that the plasma concentrations of copper in Australian Thoroughbred and Stock horses were generally below normal. However, they correctly pointed out that the "normal" level needs more definition and the Australian horses were apparently healthy.

The 1989 values for the other trace minerals are compared to the 1978 values in table 2.

TABLE 2 Dietary Concentrations of Minerals Adequate for Horses

	1978	<u>Growth or Maintenance</u>	1989
		(ppm)	
Copper	9		10
Manganese	40		40
Zinc	40		40
Selenium	0.1		0.1
Iodine	0.1		0.1
Cobalt	0.1		0.1

Vitamins

Vitamin A requirements were estimated to be 60 IU/day/kg bodyweight for pregnant and lactating mares and 30 IU/day/kg body weight for all other classes of horses. Thus a 500 kg mare at maintenance or pregnant would require 15,000 or 30,000 IU/day. These values are slightly increased over the 12,500 and 25,000 IU given in the 1978 edition.

A summary of the estimates of requirements for some other vitamins is shown in table 3. The biggest change is for vitamin E. More discussion of the vitamin E requirement will be given in my other paper presented at this meeting. It was decided that data are insufficient to determine a requirement for pantothenic acid, B₆, B₁₂, folic acid, biotin or ascorbic acid.

TABLE 3 Dietary Concentration of Vitamins Adequate for Horses^a

	Maintenance		Growth	
	1978	1989	1978	1989
Vitamin D (IU/kg)	275	300	275	300
Vitamin E (IU/kg)	15	50	15	80
Thiamin (mg/kg)	3	3	3	3
Riboflavin (mg/kg)	2.2	2	2.2	2

^aDry matter basis

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