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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

This report is one of a series issued under the direction of the Committee on Animal Nutrition, Board on Agriculture and Renewable Resources, Commission on Natural Resources, National Research Council. It was prepared by the Subcommittee on Horse Nutrition and replaces the third revised edition of *Nutrient Requirements of Horses*, issued in 1973.

This revision is characterized by the following:

- The values presented in the 1978 edition reflect new information available on the nutrient requirements of horses.
- The expected growth of foals from birth to 3 months of age has been re-evaluated and substantially increased over that in the 1973 revision.
- Different energy concentrations are recommended for various classes of horses and levels of work, whereas in the previous edition, one energy concentration was used for all classes.
- The daily nutrient requirements are listed for horses of various mature weights, but the nutrient requirements expressed as percentage of diet are given only for horses of various ages and physiological states regardless of mature body size. These requirements are also expressed on a 90 percent dry matter basis.
- Feed composition data are expressed on a dry matter basis.
- Feeds are named in accordance with nomenclature adopted by the Committee on Animal Nutrition (United States) and the National Committee on Animal Nutrition (Canada).
- Both the metric and the English systems of presenting requirements are indicated in the tables in order to maintain the widest application of the information possible.

The subcommittee is indebted to Philip Ross and Selma P. Baron of the Board on Agriculture and Renewable Resources for their assistance in the production of this report, to the members of the Committee on Animal Nutrition for their suggestions, and to L. H. Breuer, Tony J. Cunha, Paul V. Fonnesbeck, Charles A. Hutton, and Glenn W. Salisbury for their comprehensive reviews and constructive comments on the report.

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INTRODUCTION

The recent increase in numbers of horses has resulted in a renewed interest in research on the nutrient requirement of horses. The results of this research coupled with those of earlier experiments provide information for estimates of the requirements for many nutrients. The estimates are summarized in Tables 1A–1D, 2A–2B, and 3.

The requirements stated herein indicate minimum levels needed to insure normal health and performance of horses. Some of the factors that should be considered when using these estimates are the following:

- Variation among horses in the utilization and need of nutrients.
- Response or performance expected from the horse.
- Interrelations among nutrients.
- Previous nutritional status of the horse.
- Disease, environment, or other conditions that may influence the horse's needs.

Thus, increased nutrient levels are needed occasionally to meet specific conditions, while in other cases, lower levels may be adequate.

NUTRIENT REQUIREMENTS AND SIGNS OF DEFICIENCY AND EXCESS

ENERGY

The energy requirements are expressed as digestible energy (DE) and total digestible nutrients (TDN). It was assumed that 4.4 Mcal of DE are equivalent to 1 kg of TDN. Net energy (NE) was not used because data were limited.

Horses consume feeds to meet their energy requirements or fill their digestive tract. When given free access to feed ingredients, they will usually select feed having a higher concentration of digestible energy; for example, horses will select high-quality hay over poor-quality hay and often prefer grain to hay. The limited capacity of the digestive tract can be used advantageously to control the energy intake of horses by feeding a combination of ingredients that will be consumed in amounts that will meet but not exceed the energy requirements. The DE concentrations presented in Tables 2A and 2B are designed for this purpose.

Maintenance

The maintenance requirement, defined as the energy required for zero body weight change plus normal activity of the nonworking horse, was estimated from several recent studies with light horses (Barth *et al.*, 1977; Stillions and Nelson, 1972; Wooden *et al.*, 1970; Hintz, 1968; Hoffman *et al.*, 1967). The estimate is expressed by the following equation:

$$\text{DE (kcal/day)} = 155\,W^{0.75}$$

where W equals weight of the horse in kilograms. As discussed in the introduction, there is a variation among animals. Some of the variation in energy requirement might be related to differences in temperament.

Work

Many factors can influence the energy requirements for work. They include intensity and duration of work, condition and training of the animals, ability and weight of the rider or driver, degree of fatigue, and environmental temperature. Energy requirements for various activities of horses are based on studies by Hintz *et al.* (1971) and Kossila *et al.* (1972):

	DE/Hour[a]	
Activity	Per kg of body weight (kcal)	Per lb of body weight (kcal)
Walking	0.5	0.2
Slow trotting, some cantering	5.0	2.3
Fast trotting, cantering, some jumping	12.5	5.7
Cantering, galloping, jumping	23.0	10.5
Strenuous effort (polo, racing at full speed)	39.0	17.7

[a] Above maintenance requirement.

Pregnancy

In the 1966 and 1973 revisions of this report, it was estimated that the products of conception contain 1,040 kcal of gross energy (GE) per kilogram and that these products amount to 12 percent of the body weight of mares weighing less than 450 kg and 10 percent for mares weighing 450 kg or more. It is assumed that the utilization of DE for growth of the fetus and associated tissues is 60 percent. Since most of this tissue growth occurs during the last 90 days of the gestation period, the added requirements were calculated only for this period. Therefore, a 500-kg mare will deposit 500 × 0.10 × 1,040 kcal (= 52,000 kcal) in the last 90 days of pregnancy. This amounts to 578 kcal of GE daily. It was assumed that only 60 percent of the DE provided in addition to that for maintenance is deposited. Therefore, the additional DE requirement for pregnancy is 963 kcal daily.

Estimates of the DE requirement for pregnancy by the above calculations resulted in values about 6 percent greater than those for maintenance. However, Ott (1971) and Breuer (1975) reported that intakes greater than 6 percent above maintenance resulted in less weight loss by the mare after foaling. Furthermore, studies with ruminants indicate that the assumption of 60 percent utilization of DE for growth of the fetus is high (Moe, 1976). Therefore, the average energy requirement for the last 90 days of pregnancy was estimated to be 12 percent greater than for maintenance. It is also recognized that the voluntary intake of hay will decrease as the fetus increases in size. Therefore, the digestible energy density of the diet should be increased during this period.

Lactation

Mare's milk was estimated to contain 475 kcal of GE per kilogram of milk (Neseni *et al.*, 1959; Ullrey *et al.*, 1966). Assuming that the horse converts DE into milk energy (GE) with 60 percent efficiency, 792 kcal of DE are required for each kilogram of milk produced. Mares of light breeds may produce as much as 24 kg of milk per day at peak lactation, which occurs at about 8 weeks, but the average production is probably within the range of 12–18 kg. It was estimated that ponies have an average daily milk production of 4 and 3 percent of body weight during early and late lactation, respectively. Horses were estimated to produce milk equivalent to 3 and 2 percent of body weight during early (1–12 weeks) and late (13–24 weeks) lactation, respectively.

Growth

Estimated growth curves of horses of various mature weights are shown in Figure 1. The curves are presented as examples rather than as models of growth curves because the question of how fast a horse should grow for maximum performance and soundness remains unresolved. Except for the nursing foal, DE required for growth, in addition to that for maintenance, was estimated from the following equation:

$$Y = 3.8 + 12.3X - 6.6X^2$$

where Y = kilocalories of DE per gram of gain and X = fraction of adult weight. The nursing foal is assumed to be approximately 10 percent more efficient in utilization of DE than are mature horses.

Energy Sources

The primary source of energy is carbohydrates, but fats and protein are also utilized. Muscle can utilize carbohydrates or free fatty acids as energy sources (Goodman *et al.*, 1973). Some dietary fiber is desirable, but the amount needed has not been determined. Olsson and Ruudvere (1955) recommended that horses be fed at least 0.6 kg of roughage per 100 kg of body weight, whereas Earle *et al.* (1943) reported that 0.4 kg of roughage per

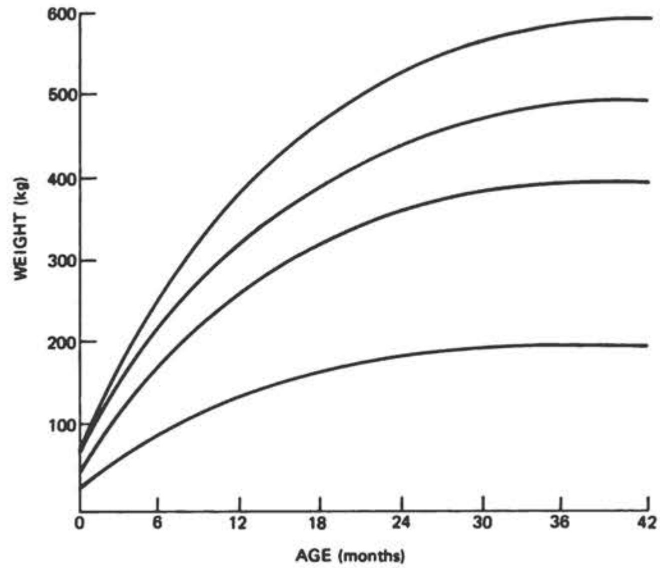


FIGURE 1 Weight gains of horses.

100 kg of body weight was adequate. Most of the soluble carbohydrates of the diet are digested in the small intestine, and the end products that are absorbed are the simple sugars. Some of the soluble carbohydrates and most of the fiber is digested by bacteria in the large intestine, and the end products are volatile fatty acids. The latter may supply 25 percent or more of the energy needed by the horse. Presumably, horses have a long-chain fatty acid requirement, but a deficiency has not been produced.

Signs of Deficiency and Excess

Deficiencies of energy result primarily in losses of weight, generally poor condition, and delayed estrus in mares. Energy-deficient young horses do not grow well and acquire an unthrifty appearance. Excess energy intake is a frequent problem. Obese horses may be more susceptible to stress and founder and have lowered reproductive efficiency and decreased longevity. Changes in the DE density of the diet from all forage to high-energy feeds should be gradual to avoid an abnormal fermentation that can result in products that are toxic to the horse.

PROTEIN

Digestibility

The apparent digestibility of protein depends on the source and amount in the diet. Equations for estimating apparent digestible crude protein (DP) were determined by calculating the regression of the percentage of DP on the crude protein (CP) content of the diet ($Y = bX + a$). The regression coefficient (b) estimates the true digestibility of protein. The regression constant (a) estimates the metabolic fecal protein.

For a grass forage diet,

$$\text{DP}\,\% = 0.74\ \text{CP}\,\% - 2.5^{*}$$

For an alfalfa concentrate diet (1:1 ratio),

$$\text{DP}\,\% = 0.95\ \text{CP}\,\% - 4.2^{*}$$

Slade *et al.* (1970) developed an equation for converting crude protein to digestible protein in oat-hay concentrate diets:

$$\text{DP}\,\% = 0.80\ \text{CP}\,\% - 3.3$$

Protein Quality

Synthesis of microbial protein occurs in the cecum and colon of the horse (Reitnour *et al.*, 1970; Chandler *et al.*, 1976). But it is not known how efficiently the microbial protein is digested and absorbed from the cecum and colon (Slade *et al.*, 1970; Wysocki and Baker, 1975).

Rapid and efficient gains in weanlings are more likely when the amino acid composition of the diet approximates the requirement of other nonruminant animals. Increasing the lysine concentrations of corn and sorghum grain diets (Breuer and Golden, 1971; Potter and Huchton, 1975) or replacing linseed protein with milk protein or supplementing linseed protein with lysine (Hintz *et al.*, 1971) significantly increased growth rate and feed efficiency of young horses.

Nonprotein Nitrogen

Nonprotein nitrogen such as urea has been used to support nitrogen balance in mature horses fed low-protein diets (Slade *et al.*, 1970; Houpt and Houpt, 1965; Nelson and Tyznik, 1971; Hintz and Schryver, 1972). Theoretically, the increased nitrogen retention could be brought about through utilization of bacterial protein (Slade *et al.*, 1970; Johnson and Hart, 1974) or endogenous protein synthesis from ammonia released by bacteria (Reitnour and Salsbury, 1973). Horses do not appear to be as susceptible to urea toxicity as are ruminants, and dietary levels of urea as high as 5 percent have been tolerated (Ratliff *et al.*, 1963; Rusoff *et al.*, 1965). However, ponies weighing 130 kg fed 450 g of urea in one feeding died as a result of ammonia toxicity (Hintz *et al.*, 1970). The urea intake was equivalent to 25 percent of the diet.

Maintenance

The protein requirement for maintenance of horses was estimated to be 2.7 g of DP/$W^{0.75}$, where W equals the weight of the horse in kilograms (Teeter *et al.*, 1967; Slade *et al.*, 1970; Hintz and Schryver, 1972; Prior *et al.*, 1974; Quinn, 1975).

The amino acid requirements for maintenance are not known. High-quality hay and grain diets usually provide ample quantities of digestible protein containing an adequate balance of amino acids for maintenance.

Growth

The body composition of the growing horse varies with age. Although the fat-free body tends to maintain a water content of 72 percent, a protein content of 22 percent, and an ash content of 6 percent (Mitchell, 1962; Robb *et al.*, 1972), the whole body may vary from 2 percent of fat at birth to 20 percent of fat for a mature horse in good condition (Widdowson, 1950; Julian *et al.*, 1956; Pitts and Bullard, 1968). The percentage of body fat between birth and maturity was estimated from the following equation:

$$\text{Fat}\,\% = 0.1388\ (\%\ \text{mature wt}) + 1.111$$

This estimate was based on the assumption that the percentage of body fat increases linearly from 2.5 percent at birth to 15 percent at maturity. As the percentage of fat increases, the percentage of protein decreases. The protein content for each stage of maturity was estimated from the following equation:

$$\text{Protein}\ \% = 0.22\ (100 - \%\ \text{of body fat})$$

The DP requirement for growth in addition to the maintenance requirement was estimated from the following equation:

$$\text{DP for growth (g/day)} = \frac{\text{Body protein concentration} \times \text{g of gain/day}}{0.45}$$

This equation was based on the assumption that after maintenance requirements are met, 45 percent of the remaining DP is utilized for growth. When protein of marginal quality is fed, the dietary amount of protein must be increased to provide the essential amino acid needs. Young horses must have adequate levels of essential amino acids for growth. Weanlings require 0.6 to 0.7 percent lysine, and yearlings, 0.4 percent in the diet (Breuer and Golden, 1971; Hintz *et al.*, 1971).

Work

There is little or no increase in dietary protein requirements above maintenance levels for work (Nitsche, 1939; Harvey *et al.*, 1939). A small amount of nitrogenous compounds, including protein, is lost in sweat, but the magnitude of this loss has not been measured experimentally to determine the increment by which protein should be increased to replace it. The assumption that muscle is used up during strenuous exercise and must be

* P. V. Fonnesbeck, Animal Science Department, Utah State University (unpublished data).

replaced is erroneous. Recent research suggests that feeding excessive levels of protein to the working horse may be detrimental to optimal performance due to increased heart and respiration rates and sweating (Slade *et al.*, 1975). The energy requirement for work is met by feeding greater amounts of the concentrate. This practice will provide sufficient protein to replace any nitrogen lost in sweat.

Pregnancy

The recommended daily maintenance requirement for protein should be adequate for conception if the mare is not also lactating at breeding time. Feeding mares a maintenance diet during early gestation appears reasonable because fetal growth rate is extremely low and protein utilization is probably highly efficient. In the last 90 days of gestation, the protein requirement will increase considerably.

It is assumed that the products of conception total 12 percent of the body weight of mares weighing less than 450 kg and 10 percent for mares weighing 450 kg or more (see p. 2). The products of conception contain about 11.3 percent protein. Therefore, the protein content of the products of conception are estimated as 1.36 percent of the mare's body weight (0.12 × 11.3 percent) for mares under 450 kg and 1.13 percent of the mare's body weight (0.10 × 11.3 percent) for mares 450 kg and over. It is assumed that 60 percent of the protein in the fetus is deposited during the last 90 days of gestation (Bergin *et al.*, 1967) and that the utilization of digested protein for fetal growth is 45 percent. The protein needed for products of conception for mares under 450 kg would be

$$\frac{0.60 \times 1.36\%}{0.45} = 1.81\% \text{ of mare's weight (kg)}$$

For mares over 450 kg, it would be

$$\frac{0.60 \times 1.13\%}{0.45} = 1.51\% \text{ of mare's weight (kg)}$$

The daily DP requirement for growth of the products of conception can be calculated as follows:

DP (g/day) for mares under 450 kg

$$\frac{0.0181 \times \text{mare's weight (kg)}}{90 \text{ days}} = 0.20 \text{ g DP/mare's weight (kg)}$$

DP (g/day) for mares 450 kg and over

$$\frac{0.0151 \times \text{mare's weight (kg)}}{90 \text{ days}} = 0.17 \text{ g DP/mare's weight (kg)}$$

The protein requirement for maintenance of the products of conception and the mare is estimated at 2.7 g of DP per $W_{kg}^{0.75}$. Thus, the DP requirements for growth and maintenance of the products of conception and for maintenance of the mare are estimated as follows:

DP (g/day) for mares under 450 kg
= 0.20 g DP/mare's $W_{kg}^{0.75}$ + 2.7 g DP/pregnant mare's $W_{kg}^{0.75}$

DP (g/day) for mares 450 kg and over
= 0.17 g DP mare's $W_{kg}^{0.75}$ + 2.7 g DP/pregnant mare's $W_{kg}^{0.75}$

Lactation

The protein concentration of milk 5 days after parturition is about 3.1 percent and declines to about 2.2 percent in 2 months (Ullrey *et al.*, 1966). An allowance of 45 percent in excess of that appearing in the milk will provide adequate DP for lactation. The lactation requirements were calculated on the basis of 2.2 percent and 2.0 percent protein in the milk in early and late lactation, respectively. Daily milk production is discussed in the section on energy (see "Lactation," p. 3).

Signs of Deficiency

Depressed appetite is the primary sign of protein deficiency. The depressed appetite leads to inadequate consumption of energy; thus, protein deficiency and energy deficiency often occur together.

Loss of weight occurs in mature horses. Slow, inefficient growth and underdevelopment occur in young horses. Other possible results of protein deficiency include reduced fertility and reduced milk production.

WATER

An adequate supply of water is essential at all times, and the requirement is increased during periods of growth, work, and lactation. Work may increase the water need about 20–300 percent, and lactation may increase it 50–100 percent above maintenance. The tissue of young horses contains 70–80 percent water, demonstrating the need of water for growth.

One of the most important factors influencing water intake is the dry matter intake. Fonnesbeck (1968) reported a correlation of 0.91 between water intake and dry matter consumption. A review of several studies suggests that a horse needs 2–4 liters of water per kilogram of dry matter intake. However, the water requirement is affected by many factors. A rise in the environmental temperature from 13°C to 25°C increased the water requirement by 15–20 percent (Caljuk, 1961). The amount of water lost in the feces is also a factor, and diarrhea is one of the most common causes of dehydration. Water deprivation can lead to digestive disturbances such as colic (Argenzio *et al.*, 1974). Neglect is one of the most common causes of water deprivation.

MINERALS AND SIGNS OF DEFICIENCY AND EXCESS

Minerals are involved in a number of functions in the body, including formation of structural components, enzymatic cofactors, and energy transfer, and as integral parts of vitamins, hormones, and amino acids. The horse obtains most of the needed minerals from pasture, roughage, and grain. Mineral content of the feeds and availability of minerals will vary with soil mineral content, plant species, stage of maturity, and methods and conditions of harvesting. The resulting variations must be considered in assessing an animal's mineral status and formulating appropriate diets. Mineral content of the total diet should be monitored frequently. Signs of deficiency and excesses are not always apparent and may not be detected until irreversible damage has occurred.

Calcium and Phosphorus

The calcium and phosphorus requirements of the horse have recently received considerable attention. These elements are essential to sound bone structure and are involved in other important body functions. Under maintenance conditions, endogenous losses of these minerals must be replaced. Endogenous losses of 25 mg of calcium and 10 mg of phosphorus per kilogram of body weight per day have been suggested (Schryver *et al.*, 1970, 1971a,b). The efficiency of true absorption varies with source and dietary level. Horses absorb 55–75 percent of calcium and 35–55 percent of phosphorus in typical horse diets. To account for these levels of absorption, the dietary requirements for maintenance are estimated at 33.3–45.5 mg of calcium per kilogram of body weight per day and 22.2–28.6 mg of phosphorus per kilogram of body weight per day. For a 500-kg mature horse, this is 16.6–22.8 g of calcium and 11.1–14.3 g of phosphorus. Absorption values of 55 percent for calcium and 35 percent for phosphorus were used in Tables 1A–1D for all horses except the nursing foal, which was calculated at 70 percent calcium absorption and 55 percent phosphorus absorption because of greater availability of the minerals in milk.

Requirements for optimal bone development during growth are difficult to establish without definitive measurements of bone development. Growing horses deposit an average of 16 g of calcium and 8 g of phosphorus per kilogram of body weight gained (Schryver *et al.*, 1974). Working horses will lose some calcium and phosphorus in the sweat; however, no direct measurements of this loss have been made to date.

The pregnant mare deposits an amount equivalent to 10–12 percent of her body weight in the products of conception. Products of conception are estimated to contain 1.2 percent calcium and 0.6 percent phosphorus. Since most of these minerals are deposited in the bones, and approximately 90 percent of bone development occurs during the last 90 days of gestation, about 6 g of calcium and 3 g of phosphorus per day will be deposited during this period in a 500-kg pregnant mare.

Calcium and phosphorus requirements for lactation depend on level of production. Milk production varies among mares and with stage of lactation (Neuhaus, 1959). Production by the 500-kg mare during the first 3 months of lactation is estimated to be 15 kg per day and to contain 1.0 g of calcium and 0.45 g of phosphorus per kilogram of milk (Ullrey *et al.*, 1966). The mare will thus deposit in the milk 15.0 g of calcium and 6.8 g of phosphorus per day.

The ratio of calcium to phosphorus in the diet must be considered. When the phosphorus intake is greater than that of calcium, the absorption of calcium may be reduced (Schryver *et al.*, 1971a, b) resulting in calcium deficiencies (Krook and Lowe, 1964; Joyce *et al.*, 1971). Therefore, the calcium:phosphorus ratio should not be less than 1:1. Calcium to phosphorus ratios of 6:1 do not appear to be detrimental to mature horses if phosphorus intake is adequate. Foals and yearlings have been fed calcium to phosphorus ratios up to 3:1 without problems (Jordan *et al.*, 1975).

Signs of Deficiency and Excess

Inadequate calcium or phosphorus intake by the developing foal will result in inadequate mineralization of the osteoid tissue and subsequent bone problems, including crooked bones and enlarged joints. Inadequate calcium or phosphorus in the mature horse results in weakening of the bones and in insidious shifting lameness (Krook and Lowe, 1964). Calcium blood levels are not reliable indicators of calcium status, because homeostatic mechanisms of the parathyroid gland maintain normal blood calcium levels even when the diet is deficient (Krook and Lowe, 1964).

Calcium has been fed at levels over 5 times the requirement without detrimental effect, providing the level of phosphorus is adequate to compensate for reduced absorption (Jordan *et al.*, 1975). Excess phosphorus in the presence of low levels of calcium, such as that found when high-grain diets are fed, causes nutritional secondary hyperparathyroidism resulting in osteofibrosis. Enlargement of the jaw and facial crest (big head) is common in advanced cases (Krook and Lowe, 1964).

Salt (Sodium Chloride)

Prolonged exercise and elevated temperatures will increase the needs for sodium and chloride, since sweat contains considerable quantities of salt. The requirements have not been determined, but if salt is fed at a rate of 0.5–1 percent of the diet or is ingested free choice, a deficiency is not likely to occur.

Generally, chlorine requirements will be met if sodium needs are supplied by sodium chloride.

Signs of Deficiency and Excess

Long-term salt deficiency has not been studied in horses, but it results in depraved appetite, rough hair coat, reduced growth, and reduced milk production in other species.

Excessive salt intake may result in high water intake, excessive urine excretion, digestive disturbances, or death from salt cramps. There is little likelihood that horses will consume toxic amounts of salt unless a salt-starved animal is suddenly exposed to an unlimited amount of salt or high levels of salt are fed without adequate water.

Potassium

Stowe (1971) reported that a purified diet for young horses should contain 1 percent potassium. The requirement of the mature horse is estimated to be 60 mg per kilogram of body weight or about 0.4 percent of the diet (Hintz and Schryver, 1976). Since most forages contain at least 1.5 percent potassium, a diet containing at least 35 percent forage can be expected to provide adequate potassium.

Signs of Deficiency

Deficiency results in decreased rate of growth, reduced appetite, and hypokalemia (decreased serum level of potassium).

Magnesium

The endogenous excretion of magnesium by the mature horse is estimated at 5.0 mg per kilogram of body weight per day, and absorption varies from 40 to 60 percent (Meyer, 1960; Hintz and Schryver, 1972; 1973). The horse, therefore, requires 8–13 mg of dietary magnesium per kilogram of body weight per day for maintenance or 4–6.5 g daily for a 500-kg horse, which is equivalent to 0.09 percent. The growing foal must meet maintenance requirements for magnesium plus an additional 0.85–1.25 g of magnesium per kilogram of body weight gain (Schryver *et al.*, 1974).

Signs of Deficiency

Although tetany and death have been reported in cattle grazing forages growing on low-magnesium soils, horses grazing the same pastures are seldom affected. Foals fed a purified diet containing 8 mg of magnesium per kilogram of feed developed signs including hypomagnesemia, nervousness, muscular tremors, and ataxia followed by collapse, with hyperpnea, sweating, convulsive paddling of legs, and, in some cases, death (Harrington, 1974).

Sulfur

Information on sulfur requirements is lacking. Sulfur is an integral part of the amino acids methionine and cystine. Adequate intake of high-quality protein will usually provide at least 0.15 percent sulfur in this form. This level of intake appears to be adequate.

Iron

Iron deficiency will result in anemia. The maintenance requirement for iron is estimated to be less than 40 mg per kilogram of diet. For rapidly growing foals, the requirement is estimated to be 50 mg per kilogram of diet. Most feeds contain adequate levels of iron, and the body effectively conserves the iron supply. Iron deficiency and anemia may result when the horse is heavily parasitized.

Zinc

Zinc deficiency occurred in foals fed a purified diet containing 4 mg of zinc per kilogram of diet but not when 40 mg of zinc per kilogram of diet was fed (Harrington *et al.*, 1973). Foals consuming a natural diet containing 41 mg of zinc per kilogram of diet gained weight at acceptable rates and maintained normal body stores (Schryver *et al.*, 1974). The addition of 5 mg per kilogram of diet to a diet containing 35 mg per kilogram of diet prevented a decrease in serum zinc in pregnant mares and a decrease in milk zinc during late lactation (Kruzkova, 1968).

Signs of Deficiency and Excess

Zinc deficiency in the foal is accompanied by reduced growth rate, cutaneous lesions on the lower extremities, alopecia, reduced tissue and blood zinc, and reduced blood alkaline phosphatase activity (Harrington *et al.*, 1973).

Intakes up to 700 mg of zinc per kilogram of diet daily were not detrimental to mares or their foals (Graham and Hester, 1940). Foals fed 90 g per day (equivalent to 2 percent of the diet) developed enlarged epiphyses followed by stiffness, lameness, and increased tissue zinc levels (Willoughby *et al.*, 1972a).

Manganese

The manganese requirements of the horse are not known. Data from other species suggest that 40 mg per kilogram of diet should be adequate (Rojas *et al.*, 1965). Manganese deficiency in other species results in abnormal bone development. Excess manganese intake may result in anemia (Svanberg, 1938).

Copper

Foals grew satisfactorily when fed 9 mg of copper per kilogram of diet (Cupps and Howell, 1949).

Signs of Deficiency and Excess

Stowe (1968) reported an apparent relationship between low serum copper levels and hemorrhaging in aged parturient mares, suggesting either reduced absorption of copper with age or reduced ability to mobilize stores.

Copper intakes of 791 mg per kilogram of feed for 183 days resulted in copper accumulation in the liver of pregnant pony mares but did not adversely affect the mares or foals (Smith *et al.*, 1975).

Cobalt

An intake of 0.1 mg of cobalt per kilogram of diet should be adequate. The only known role of cobalt in the horse is as an integral part of cobalamin (see "Vitamins," p. 10). Horses have remained in good health while grazing pastures so low in cobalt that ruminants confined to them have died (Filmer, 1933).

Iodine

The iodine requirement is estimated to be 0.1 mg per kilogram of diet (Rodenwald and Simms, 1935).

Signs of Deficiency and Excess

Pregnant mares may not show external signs of iodine deficiency but may produce weak foals with enlarged thyroid glands and a high mortality. Deficient mares may exhibit abnormal estrus cycles (Kruzkova, 1968).

Consumption of 48 mg or more of iodine per day by pregnant mares is excessive and has resulted in the birth of goitrous foals (Baker and Lindsey, 1968; Drew *et al.*, 1975). Feeding excessive amounts of certain kinds of seaweed (kelp) can be detrimental because of the high iodine content.

Selenium

The selenium requirement of the horse is estimated to be 0.1 mg per kilogram of diet (Stowe, 1967).

Signs of Deficiency and Excess

Selenium deficiency results in reduced serum selenium and elevated serum glutamic-oxalacetic transaminase levels (Stowe, 1967). White muscle disease in foals, which can be prevented by selenium injection, has occurred in several countries. At necropsy, the affected foals usually have alopecia, degenerative skeletal muscle, yellow-brown fat, and many small hemorrhages (Dodd *et al.*, 1960; Hartley and Grant, 1961; Wilson *et al.*, 1976; Schougaard *et al.*, 1972).

Horses consuming forages from seleniferous soils develop selenium toxicosis (seleninosis) (Moxon, 1937). The disease, known as blind staggers or alkali disease, is characterized by loss of appetite, hair loss from the mane and tail, and rings on the hoof. In advanced stages, loss of hoofs, blindness, and paralysis occur. The toxicity has occurred in horses consuming forages containing 5–40 mg of selenium per kilogram of dry matter.

Fluorine

Fluorine is known to be involved in bone and teeth development in other species, but its dietary essentiality for horses has not been established.

Signs of Excess

Horses appear to be more tolerant of excess fluorine than are cattle. Excess intake will result in discolored teeth (fluorosis), bone lesions, lameness, and unthriftiness. Horses will tolerate 50 mg of fluorine per kilogram of diet for extended periods without detrimental effects (Shupe and Olson, 1971).

Lead

Lead is not considered to be an essential dietary constituent.

Signs of Excess

Lead toxicity is characterized by pharyngeal paralysis, regurgitation of food and water, paralysis of the lips, muscular weakness, stiffness of joints, general paralysis, convulsions, severe abdominal pain, diarrhea, and death (Blood and Henderson, 1968). Horses consuming forage containing about 80 mg of lead per kilogram of feed developed toxicity symptoms (Aronson, 1972). The consumption of 30 mg of lead per kilogram of feed by foals for 15 weeks increased body lead stores but did not result in any toxicity (Willoughby *et al.*, 1972b).

VITAMINS AND SIGNS OF DEFICIENCY AND EXCESS

The vitamin requirements, like other nutrients, are affected by the stage of production, age, and stress imposed upon the horse. The need to add vitamins to the diet depends on the type and quality of the diet (high-quality forages are excellent sources of most vitamins), the extent of synthesis in and absorption from the digestive tract, and, in the case of vitamin D, access to sunlight.

Fat-Soluble Vitamins

Vitamin A

The vitamin A requirement can be met by carotene, a plant precursor of vitamin A, or by synthetic vitamin A supplements. Carotene is unstable in the presence of light and high temperature and gradually decreases in hay during storage. Carotene content in dry summer grasses was lower than in rapidly growing grasses and resulted in lower liver, fat, and blood concentrations of carotene and vitamin A in horses (Garton *et al.*, 1964). The conversion of carotene by horses to vitamin A is not very efficient, particularly that of carotene from grass forages (Fonnesbeck and Symons, 1967). Thus, the use of carotene values as presented in the literature may exaggerate the value of carotene as a source of vitamin A for horses. However, in this report it is assumed that 1 mg of carotene is equivalent to 400 IU of vitamin A. Horses that have been consuming fresh green forage for a period of 4–6 weeks will have sufficient vitamin A stored in their livers to maintain adequate levels of plasma vitamin A for 3–6 months even when consuming submarginal levels of carotene or vitamin A.

It is estimated that 25 IU of vitamin A per kilogram of body weight are adequate for maintenance and that 40 IU per kilogram are adequate for weanlings. As the rate of growth decreases with age, the requirement decreases toward that of maintenance. Levels of 50 IU per kilogram of body weight are adequate for pregnancy and lactation. However, requirements for lactation are influenced by the level of milk production. In order to arrive at the requirement for lactation, the amount of vitamin A in the milk has been added to the basic body requirement. It was assumed that the milk contained 1,000 IU of vitamin A per kilogram of milk and that the daily milk production was 3 percent of body weight in early lactation and 2 percent of body weight in late lactation.

Signs of Deficiency and Excess A deficiency of vitamin A is characterized by anorexia, poor growth, night blindness, lacrimation, keratinization of the cornea and skin, respiratory symptoms, abscess of the sublingual glands, reproductive problems, convulsive seizures, and progressive weakness (Howell *et al.*, 1941; Stowe, 1968a). Stowe noted that 9.5 to 11 IU of vitamin A per kilogram of body weight would prevent these symptoms.

Prolonged feeding of excess vitamin A may cause bone fragility, hyperostosis, and exfoliated epithelium.

Vitamin D

Vitamin D requirements have not been adequately established. A diet providing 6.6 IU of vitamin D per kilogram of body weight is sufficient under most circumstances. Horses normally obtain sufficient vitamin D from sun-cured forages or from exposure to sunlight.

Signs of Deficiency and Excess Vitamin D has a positive relationship to calcium and phosphorus absorption in horses (Hintz *et al.*, 1973). A deficiency of vitamin D is characterized by reduced bone calcification, stiff and swollen joints, stiffness of gait, and reduction in serum calcium and phosphorus.

An excess intake of vitamin D is characterized by calcification of the blood vessels, heart, and other soft tissues and by bone abnormality (Bille, 1971; Hintz *et al.*, 1973). The toxic level in horses has not been definitely established, but a level of 50 times the requirement may be harmful. High calcium intake aggravates vitamin D toxicity.

The excessive use of vitamin D supplements can be harmful. Young ponies fed 3,300 IU per kilogram of body weight per day died within 4 months. Soft tissue calcification, generalized bone resorption, and kidney damage were extensive (Hintz *et al.*, 1973). *Cestrum diurnum* (jessamine, wild jasmin, king-of-the-day), an ornamental plant containing a substance similar to the vitamin D metabolite 1,25-dihydroxycholecalciferol was recently reported to cause lameness and death of horses in Florida (Krook *et al.*, 1975). Extensive calcium deposits were found in ligaments, tendons, and blood vessels. Osteopetrosis (dense bones) was also reported. The plant was introduced to Florida a few years ago and has spread rapidly and can be found in several subtropical areas such as parts of Texas and California.

Vitamin E

The requirements for vitamin E have not been established. Foals deficient in vitamin E required 27 μg of parental or 233 μg of oral alpha-tocopherol per kilogram of body weight daily to maintain erythrocyte stability (Stowe, 1968a). Combinations of selenium and vitamin E have been used in the treatment of the syndrome "tying-up" in horses. (Tying-up is characterized by lameness and rigidity of the muscles of the loin. The urine may be coffee-colored because of the myoglobin released from the damaged muscle cells.) However, no experimental evidence to confirm the value of vitamin E on the condition has been provided. Alpha-tocopherol was ineffective in preventing muscular degeneration in yellow fat disease in foals (Dodd *et al.*, 1960). There is no clear substantial evidence to indicate that dietary supplementation of vitamin E helps resolve reproductive problems in horses.

Vitamin K

It is assumed that vitamin K is synthesized in adequate amounts by the intestinal microflora of the horse. No deficiencies have been reported.

Water-Soluble Vitamins

The B-complex vitamins are usually supplied in adequate amounts in good-quality forage. The amount of B vitamins supplied in food, coupled with abundant synthesis in the intestine, results in sufficient amounts for most horses.

Horses under severe stress may have vitamin requirements in excess of the requirement for maintenance and growth. Critical experimentation should be conducted with performing horses to determine their vitamin needs.

Thiamin

A thiamin requirement has not been established, but 3 mg per kilogram of diet will maintain appetite and feed intake, body weight gains, and normal levels of thiamin in the skeletal muscle of growing horses (Carroll, 1950). There is considerable synthesis of thiamin in the digestive tract (Carroll, 1950). Linerode (1966) estimated that 25 percent of the free thiamin in the cecum is absorbed by the horse.

Both grains and forages usually contain more than 3 mg of thiamin per kilogram of feed. Therefore, the dietary intake coupled with synthesis in the intestinal tract suggest little need for thiamin supplementation under most situations. Thiamin injections are used in the treatment of "tying-up" in race horses, although experimental evidence as to the value of thiamin is not available.

Signs of Deficiency Experimentally produced thiamin deficiency caused anorexia, loss of weight, incoordination (especially in the hind legs), lower blood thiamin, elevated blood pyruvic acid, and dilated and hypertrophied heart (Carroll *et al.*, 1949). Martin (1975) noted that horses that had been poisoned by yellow star thistle (*Centaurea solstitialis*) causing glossopharyngeal paralysis recovered following 5–7 days administration of 1 g of thiamin daily. Supplemental thiamin is beneficial in the treatment of thiamin deficiencies resulting from bracken fern poisoning (Lott, 1951).

Riboflavin

It has been calculated that 2.2 mg of riboflavin per kilogram of feed will satisfy maintenance requirements (Pearson *et al.*, 1944). In early studies, riboflavin deficiencies were incriminated as a cause of periodic ophthalmia (recurrent uveitis) (Jones *et al.*, 1945), but there is no substantial evidence to link riboflavin and periodic ophthalmia in horses. Leptospirosis (Roberts, 1958), onchocerca cervicalis microfilaria (Cello, 1962), and several other conditions have been implicated in the production of ophthalmia.

Niacin

No requirements for niacin have been established for the horse. Niacin can be synthesized from tryptophan (Schweigert *et al.*, 1947), suggesting that a dietary source is unnecessary. Pearson and Leucke (1944) observed that horses consuming 0.01 mg of nicotinic acid per kilogram of body weight excreted more than they consumed. Protein supplements, forages, and most grains are good sources of niacin.

Pantothenic Acid

There is no known dietary requirement for pantothenic acid, but 0.015 percent of the diet should be adequate, and pantothenic acid is richly supplied by most feeds. Pearson and Schmidt (1948) reported that urinary excretion of pantothenic acid varies with intake, but they noted no difference in growth when the horse consumed from 38 to 150 μg per kilogram of body weight.

Vitamin B_{12}

The requirement for vitamin B_{12} for horses has not been reported. Kureeva (1960) observed that supplemental vitamin B_{12} increased the cobalamin concentration in the blood of weaned foals and suggested that foals might benefit from receiving supplementation of vitamin B_{12} or cobalt. Alexander and Davies (1969) noted that while intramuscular injections of vitamin B_{12} resulted in a rapid rise in serum levels of vitamin B_{12}, the oral administration of cobalt over a 7-month period failed to produce any clearly defined rise in serum levels of vitamin B_{12}. There was a tendency for higher levels of cobalamin to be observed in serum and urine and an appreciable increase in fecal excretion following cobalt administration, suggesting that cobalt stimulated microbial synthesis of vitamin B_{12}. Stillions *et al.* (1971b) observed that mature horses receiving 6 μg of vitamin B_{12} per day for 11 months showed no change in hemoglobin or hematocrit levels and that when horses received either 6 or 400 μg of vitamin B_{12} per day, they excreted more than they consumed. It was concluded that, for mature horses, supplemental vitamin B_{12} was not necessary. Davies (1968, 1971) reported an increase in vitamin B_{12} in the contents of the alimentary canal from the stomach to the rectum and identified some of the micro-organisms responsible for the synthesis of the vitamin. Salminen (1975) indicated that vitamin B_{12} was absorbed from the large intestine of horses.

Other B-Complex Vitamins

Carroll *et al.* (1949) observed that pyridoxine, folic acid, and biotin are synthesized in the lower digestive tract of the horse, but information on their dietary requirements is lacking. Seckington *et al.* (1967) reported poor performance associated with low serum folic acid levels of malnourished horses and also reported that these horses responded to the administration of 20 mg of folic acid, suggesting that stabled horses may benefit from supplementary folic acid.

Ascorbic Acid

Ascorbic acid is not a dietary essential for maintenance of mature horses (Pearson *et al.*, 1943; Stillions *et al.*, 1971a). Davis and Cole (1943) noted a correlation between breeding performance of mares and stallions and level of ascorbic acid in their blood. However, subsequent research has been unable to repeat these results.

NUTRITIVE VALUE AND PHYSICAL CHARACTERISTICS OF SOME COMMON FEEDS

FORAGES AND OTHER ROUGHAGES

Pastures

In Table 6, pasture crops are identified by the entry "grazed" under the name of the plant (e.g., alfalfa). The nutrient content of these crops varies widely as a result of differences in species, stage of maturity, fertility of the soil, and availability of water.

The legumes, of which alfalfa and the clovers are the most important, are higher in protein, vitamins, and some minerals than are the grasses. Lush spring growth of both legumes and grasses is high in protein, vitamins, and minerals, on a dry matter basis. However, the high moisture content may prevent an active horse from consuming enough energy to meet nutritive needs. As the plants mature, the percentage of water, protein, and minerals decreases and the percentage of fiber increases.

The most popular pasture grasses for horses include bluegrass, bluestem, bromegrass, orchardgrass, cereal grasses, and coastal Bermudagrass. Mixtures of grasses and legumes are excellent and offer a number of advantages over grasses, including superior nutrient content and longer grazing seasons. Pasture species should be selected for their adaptability to the area and their nutrient composition. Summer and winter annuals can also be used as pasture sources or alternatives.

Hay

The factors that cause wide variation in the nutrient content of pasture crops have a similar effect on hay and other preserved forages. Differences in methods of preservation and processing also influence the nutrient content of preserved forages. Good-quality grass hays are palatable to horses and may be fed as the only roughage. High-quality legume hays, such as alfalfa, provide higher levels of readily utilizable soluble carbohydrates, protein, calcium, and carotene than do most grass hays (Fonnesbeck, 1969; Fonnesbeck and Symons, 1967). Legumes may also be fed as the only roughage. Mixtures of grass and legumes make excellent roughages for horses. Weathered, stemmy, or nutritionally deficient hays may be fed if adequate supplementation is provided. Moldy or dusty hay should not be fed.

Other Roughages

Oat, wheat, and barley straws, corncobs, peanut hulls, corn stover, sunflower hulls, and oat hulls have very low nutritive value and may be fed only if properly supplemented. Silage and haylage may be fed, but extreme care should be taken to prevent horses from eating silage that has molded or spoiled.

ENERGY FEEDS

Grains

All the common grains may be fed to horses. Differences in nutrient content and physical characteristics should be considered in formulating rations. Oats are the most popular grain for horses. They are higher in fiber and lower in DE than other grains, and they weigh less per unit volume. Oats may be fed whole, except to young foals.

Corn is acceptable to horses in any form. It is higher in DE and lower in protein than oats.

Barley may be fed to horses as the only grain. Barley is higher in energy than are oats, but lower than is corn. It should be steam-rolled or crimped. The outer hull adheres tightly to the groat; thus processing increases digestibility.

Sorghum grains and wheat may be fed to horses, but these small, dense grains should be rolled, cracked, steam-flaked, or coarsely ground to facilitate digestion.

Grinding produces flouring and reduces acceptability to horses. Grinding should be avoided unless the ration is subsequently pelleted. The use of pelleting has increased, and many complete pelleted feeds are on the market. Pelleted feeds have several advantages, such as reduced waste, dust, and storage space requirements.

By-Products

By-products of the food and feed industry, such as molasses, wheat bran, distillers' grains, brewers' grains, beet pulp, citrus pulp, and brewers' yeast, may provide economical sources of nutrients, impart desirable physical characteristics to the ration, or improve ration acceptability. However, none of these ingredients are necessary components of horse rations.

PROTEIN SUPPLEMENTS

Soybean meal, cottonseed meal, and linseed meal (flaxseed meal) are the most important sources of supplemental protein. Fish meal and milk protein may also be used but are generally more expensive. The value of a protein supplement depends on its DP content and its protein quality. Soybean meal, fish meal, and milk protein have protein quality superior to that of cottonseed meal or linseed meal.

FORMULATING RATIONS

Several different approaches can be used to formulate rations. Methods are described in books such as Morrison's *Feeds and Feeding* and in most of the reports on nutrient requirements of animals published by the National Academy of Sciences. However, the basic idea is to compare the animal's needs to the amount supplied and, if the nutrients are not adequate, to determine what feedstuffs should be added and how much is needed to correct the deficiency. All of the calculations in the following example are on a dry matter basis.

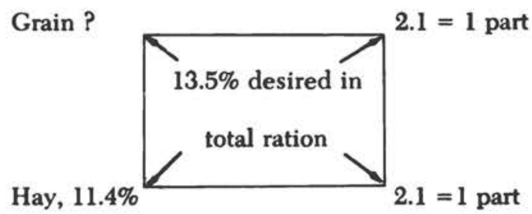
EXAMPLE: Yearling, 12 months old, weighing 325 kg, with expected mature weight of 500 kg. The hay available is timothy.

1. Compare the nutrient content of the forage with the requirements of the horse. Use actual analysis if available; if not, use Tables 6 and 8.

	Digestible Energy (Mcal/kg)	Protein (%)	Calcium (%)	Phosphorus (%)	Vitamin A (IU/kg)
Forage supplies	2.2	11.4	0.45	0.20	3,600
Horse needs	2.9	13.5	0.55	0.40	2,000

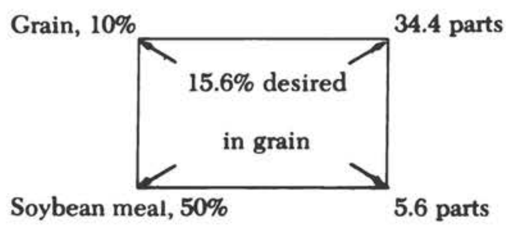
The conclusions are that timothy hay alone is lacking in energy, protein, calcium, and phosphorus concentration. Therefore, a grain supplement rich in these nutrients must be added. According to Table 1C, the yearling will eat 5.8 kg of a ration containing 2.9 Mcal of DE per kilogram. A mixture of equal parts of hay containing 2.2 Mcal per kilogram and grain with 3.6 Mcal per kilogram would provide 2.9 Mcal per kilogram. Corn and oats in equal parts would provide 3.6 Mcal per kilogram.

2. Calculate the protein. The yearling required 13.5 percent protein in the total ration. One part of hay with 11.4 percent protein plus 1 part of grain (corn + oats, equal parts) with 10 percent protein = 21.4/2 = 10.7 percent protein in the total ration. The square method can be used to calculate what level of protein is required in the grain ration in order to correct the protein deficiency of the hay and corn-oats ration.



The difference between the percent protein in the hay and the desired level (13.5 percent) is 2.1 percent, which is equivalent to 1 part of the ration. Therefore, 2.1 percent (1 part) added to 13.5 percent gives 15.6 percent, the required percentage of protein in the grain ration. That is, 15.6 percent plus 11.4 percent = 27/2 = 13.5 percent in the total ration.

The same square method can be used to determine how much protein supplement should be added to the grain in order to attain a mixture with 15.6 percent protein. Assume that soybean meal contains 50 percent protein.



Subtracting diagonally, it is determined that a mixture of 34.4 parts of grain and 5.6 parts of soybean meal would result in a concentrate containing 15.6 percent protein or, in other words, (34.4/40.0) = 86 percent corn-oats and (5.6/40.0) = 14 percent soybean meal is needed. Check to be certain that the protein level is adequate. According to Table 1, the yearling needs 0.76

kg of crude protein daily. Multiply the amount fed by the concentration.

$$2.9 \text{ kg of hay} \times 11.4\% = 0.33 \text{ kg of protein}$$

$$2.9 \text{ kg of grain} \times 15.6\% = 0.45 \text{ kg of protein}$$

A total of 0.78 kg, which is adequate, results.

3. Now determine the calcium and phosphorus status. Again multiply amount fed by concentration.

For calcium,

$$2.9 \text{ kg of hay} \times 0.45\% \text{ Ca} = 0.013 \text{ kg} \times 1{,}000 = 13 \text{ g}$$

$$2.9 \text{ kg of grain} \times 0.90\% \text{ Ca}^* = 0.0026 \text{ kg} \times 1{,}000 = 2.6 \text{ g}$$

The total is 15.6 g.

For phosphorus,

$$2.9 \text{ kg of hay} \times 0.20\% \text{ P} = 0.0058 \text{ kg} \times 1{,}000 = 5.8 \text{ g}$$

$$2.9 \text{ kg of hay} \times 0.39\% \text{ P}^\dagger = 0.013 \text{ kg} \times 1{,}000 = 11.3 \text{ g}$$

The total is 17.1 g.

* Corn contains 0.02 percent Ca; oats, 0.11 percent Ca; and soybean meal, 0.31 percent Ca. Therefore, (0.43 × 0.02) + (0.43 × 0.11) + (0.14 × 0.31) = 0.09 percent Ca in the mixture.
† Corn contains 0.31 percent P; oats, 0.37 percent P; and soybean meal, 0.71 percent P. Therefore, (0.43 × 0.31) + (0.43 × 0.37) + (0.14 × 0.71) = 0.39 percent P in the mixture.

Subtract the amount of calcium and phosphorus supplied from the amount needed:

Yearling requires	31 g of Ca	22 g of P
Hay and grain supply	15.6	17.1
Additional needed	15.4 g	4.9 g

When phosphorus is supplied by dicalcium phosphate containing 24 percent calcium and 19 percent phosphorus, divide amount needed by concentration: 4.9 g/0.19 = 26 g of dicalcium phosphate needed or 0.026 kg/2.9 kg grain = 0.9 percent of the grain mixtures.

The 26 g of dicalcium phosphate would also supply 26 g × 0.24 = 6.2 g of calcium. Therefore 15.4 − 6.2 = 9.2 g of calcium is still needed. Limestone contains 36 percent calcium. Therefore, 2.9 g/0.36 = 25.5 g of limestone or 0.0255/24 = 0.9 percent of the grain mixture.

The same approach can be used for the other nutrients.

COMPOSITION OF FEEDS

Table 6 gives the composition of feeds commonly used in horse diets.* Two larger compilations are available.†

NOMENCLATURE

In previous National Research Council nutrient requirement reports, the names of the feeds gave considerable detail as to the way the feed was processed and the grade or quality designation. In this publication, short names are used. A complete short feed name consists of as many as eight components. However, only enough components are used to be able to identify the feed. The components are as follows:

- Origin (or parent material)
- Species, variety, or kind
- Part eaten
- Process(es) and treatment(s) undergone before fed to animal
- Stage of maturity
- Cutting or crop
- Grade or quality designation
- Classification

Feeds of the same origin (and the same species, variety, or kind, if one of these is stated) are grouped into eight classes. The numbers and classes they designate are as follows:

1. Dry forages and roughages
2. Pasture, range plants, and forages fed green
3. Silages
4. Energy feeds
5. Protein supplements
6. Minerals
7. Vitamins
8. Additives

Dry feeds with more than 18 percent of crude fiber are classified as forages or roughages. Feeds that contain 20 percent or more of protein are classified as protein supplements. Products that contain less than 20 percent of protein and less than 18 percent of crude fiber are classified as energy feeds.

Abbreviations have been devised for some of the terms in the short feed names (Table 4).

A six-digit "International Feed Number" is listed in Table 6 for each feed. The first digit is the class of the feed. This reference number may be used as the "numerical name" of a feed when a diet with electronic computers is being made. This number is also listed after each "Legal Feed Definition" in the *Association of American Feed Control Officials Handbook.*‡

DATA

The analytical data are expressed in the metric system and are on a dry basis. Individual feed samples may vary widely from averages in the table. Variations are influenced by factors such as crop, variety, climate, soil, and length of storage. Therefore, the values given should be used with judgment to be related, if possible, to analyses about the feed on hand for critical nutrients.

See Table 5 for stages of maturity, Table 7 for mineral

* This is a modified table of that prepared by the National Research Council Subcommittee on Feed Composition—C. W. Deyoe, *Chairman;* J. R. Aitken; J. H. Conrad; L. E. Harris; P. W. Moe; R. L. Preston; and P. J. Van Soest—and the International Feedstuffs Institute, Utah State University, Logan, Utah, L. E. Harris, *Director.*

† Publication 1684, *United States-Canadian Tables of Feed Composition,* lists about 400 feeds. Publication 1919, *Atlas of Nutritional Data on United States and Canadian Feeds,* lists about 6,150 feeds. Both are published by the National Academy of Sciences, Washington, D.C.

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supplements, Table 8 for vitamin content of various feeds, Table 9 for weight-unit conversion factors, and Table 10 for weight equivalents.

ENERGY VALUE OF FEEDS

It has not been possible to obtain DE and TDN for all feeds from horse experiments conducted to date; therefore, some values were estimated from cattle and sheep data by adjusting for differences in utilization by horses.

CAROTENE CONVERSION

International standards for vitamin A activity as related to vitamin A and beta-carotene are as follows:

1 IU of vitamin A = 1 USP unit
= vitamin A activity of 0.300 μg of crystalline vitamin A alcohol, which corresponds to 0.344 μg of vitamin A acetate or 0.550 μg of vitamin A palmitate

Beta-carotene is the standard for provitamin A.

1 IU of vitamin A = 0.6 μg of beta-carotene

1 mg of beta-carotene = 1,667 IU of vitamin A

International standards for vitamin A are based on the utilization of vitamin A and beta-carotene by the rat. Since horses do not convert carotene to vitamin A in the same ratio as rats, it is suggested that the values in Table 8 (when used in connection with Tables 1 and 2) be converted as follows:

Converting mg of beta-carotene to IU of vitamin A	1 mg = 400 IU

TABLES

TABLE 1A Nutrient Requirements of Horses (Daily Nutrients per Horse), Ponies, 200 kg Mature Weight

	Weight		Daily Gain		Digestible Energy	TDN		Crude Protein		Digestible Protein		Cal-ci-um	Phos-pho-rus-	Vitamin A Activity	Daily Feed*	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1,000 IU)	kg	lb
Mature ponies, maintenance	200	440	0.0		8.24	1.87	4.12	0.32	0.70	0.14	0.31	9	6	5.0	3.75	8.2
Mares, last 90 days gestation			0.27	0.594	9.23	2.10	4.62	0.39	0.86	0.20	0.44	14	9	10.0	3.70	8.1
Lactating mare, first 3 months (8 kg milk per day)			0.0		14.58	3.31	7.29	0.71	1.56	0.54	1.19	24	16	13.0	5.20	11.5
Lactating mare, 3 months to weanling (6 kg milk per day)			0.0		12.99	2.95	6.50	0.60	1.32	0.34	0.75	20	13	11.0	5.00	11.0
Nursing foal (3 months of age)	60	132	0.70	1.54	7.35	1.67	3.68	0.41	0.90	0.38	0.84	18	11	2.4	2.25	5.0
Requirements above milk					3.74	0.85	1.87	0.17	0.37	0.20	0.44	10	7	0.0	1.20	2.7
Weanling (6 months of age)	95	209	0.50	1.10	8.80	2.0	4.40	0.47	1.03	0.31	0.68	19	14	3.8	2.85	6.3
Yearling (12 months of age)	140	308	0.20	0.44	8.15	1.85	4.07	0.35	0.77	0.20	0.44	12	9	5.5	2.90	6.4
Long yearling (18 months of age)	170	374	0.10	0.22	8.10	1.84	4.05	0.32	0.70	0.17	0.37	11	7	6.0	3.10	6.8
Two year old (24 months of age)	185	407	0.05	0.11	8.10	1.84	4.05	0.30	0.66	0.15	0.33	10	7	5.5	3.10	6.8

*Dry matter basis.

TABLE 1B Nutrient Requirements of Horses (Daily Nutrients per Horse), 400 kg Mature Weight

	Weight		Daily Gain		Digestible Energy (Mcal)	TDN		Crude Protein		Digestible Protein		Calcium (g)	Phosphorus (g)	Vitamin A Activity (1,000 IU)	Daily Feed[a]	
	kg	lb	kg	lb		kg	lb	kg	lb	kg	lb				kg	lb
Mature horses, maintenance	400	880	0.0		13.86	3.15	6.93	0.54	1.19	0.24	0.53	18	11	10.0	6.30	13.9
Mares, last 90 days gestation			0.53	1.17	15.52	3.53	7.76	0.64	1.41	0.34	0.75	27	19	20.0	6.20	13.7
Lactating mare, first 3 months (12 kg milk per day)			0.0		23.36	5.31	11.68	1.12	2.46	0.68	1.50	40	27	22.0	8.35	18.4
Lactating mare, 3 months to weanling (8 kg milk per day)			0.0		20.20	4.59	10.10	0.91	2.00	0.51	1.12	33	22	18.0	7.75	17.1
Nursing foal (3 months of age)	125	275	1.00	2.2	11.51	2.62	5.76	0.65	1.43	0.50	1.10	27	17	5.0	3.55	7.8
Requirements above milk					6.10	1.39	3.05	0.40	0.88	0.30	0.66	15	12	0.0	1.95	4.3
Weanling (6 months of age)	185	407	0.65	1.43	13.03	2.96	6.51	0.66	1.45	0.43	0.95	27	20	7.4	4.20	9.2
Yearling (12 months of age)	265	583	0.40	0.88	13.80	3.14	6.91	0.60	1.32	0.35	0.77	24	17	10.0	4.95	10.9
Long yearling (18 months of age)	330	726	0.25	0.55	14.36	3.26	7.17	0.59	1.30	0.32	0.70	22	15	11.5	5.50	12.2
Two year old (24 months of age)	365	803	0.10	0.22	13.89	3.16	6.95	0.52	1.14	0.27	0.59	20	13	11.0	5.35	11.8

[a]Dry matter basis.

TABLE 1C Nutrient Requirements of Horses (Daily Nutrients per Horse), 500 kg Mature Weight

	Weight		Daily Gain		Digestible Energy	TDN		Crude Protein		Digestible Protein		Calcium	Phosphorus	Vitamin A Activity	Daily Feed[a]	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1,000 IU)	kg	lb
Mature horses, maintenance	500	1,100	0.0		16.39	3.73	8.20	0.63	1.39	0.29	0.64	23	14	12.5	7.45	16.4
Mares, last 90 days gestation			0.55	1.21	18.36	4.17	9.18	0.75	1.65	0.39	0.86	34	23	25.0	7.35	16.2
Lactating mare, first 3 months (15 kg milk per day)			0.0		28.27	6.43	14.14	1.36	2.99	0.84	1.85	50	34	27.5	10.10	22.2
Lactating mare, 3 months to weanling (10 kg milk per day)			0.0		24.31	5.53	12.16	1.10	2.42	0.62	1.36	41	27	22.5	9.35	20.6
Nursing foal (3 months of age)	155	341	1.20	2.64	13.66	3.10	6.83	0.75	1.65	0.54	1.19	33	20	6.2	4.20	9.2
Requirements above milk					6.89	1.57	3.45	0.41	0.90	0.31	0.68	18	13	0.0	2.25	4.9
Weanling (6 months of age)	230	506	0.80	1.76	15.60	3.55	7.80	0.79	1.74	0.52	1.14	34	25	9.2	5.00	11.0
Yearling (12 months of age)	325	715	0.55	1.21	16.81	3.82	8.41	0.76	1.67	0.45	0.99	31	22	12.0	6.00	13.2
Long yearling (18 months of age)	400	880	0.35	0.77	17.00	3.90	8.58	0.71	1.56	0.39	0.86	28	19	14.0	6.50	14.3
Two year old (24 months of age)	450	990	0.15	0.33	16.45	3.74	8.23	0.63	1.39	0.33	0.72	25	17	13.0	6.60	14.5

[a]Dry matter basis.

TABLE 1D Nutrient Requirements of Horses (Daily Nutrients per Horse), 600 kg Mature Weight

	Weight		Daily Gain		Digestible Energy (Mcal)	TDN		Crude Protein		Digestible Protein		Calcium (g)	Phosphorus (g)	Vitamin A Activity (1,000 IU)	Daily Feed[a]	
	kg	lb	kg	lb		kg	lb	kg	lb	kg	lb				kg	lb
Mature horses, maintenance	600	1,320	0.0		18.79	4.27	9.40	0.73	1.61	0.33	0.73	27	17	15.0	8.50	18.8
Mares, last 90 days gestation			0.67	1.47	21.04	4.78	10.52	0.87	1.91	0.46	1.01	40	27	30.0	8.40	18.5
Lactating mare, first 3 months (18 kg milk per day)			0.0		33.05	7.51	16.53	1.60	3.52	0.99	2.18	60	40	33.0	11.80	26.0
Lactating mare, 3 months to weanling (12 kg milk per day)			0.0		28.29	6.43	14.15	1.29	2.84	0.73	1.61	49	30	27.0	10.90	23.9
Nursing foal (3 months of age)	170	374	1.40	3.08	15.05	3.42	7.53	0.84	1.85	0.78	1.72	36	23	6.8	4.65	10.2
Requirements above milk					6.93	1.58	3.47	0.51	1.12	0.38	0.84	18	15	0.0	2.25	4.9
Weanling (6 months of age)	265	583	0.85	1.87	16.92	3.85	8.47	0.86	1.89	0.57	1.25	37	27	10.6	5.45	12.0
Yearling (12 months of age)	385	847	0.60	1.32	18.85	4.28	9.42	0.90	1.98	0.50	1.10	35	25	14.0	6.75	14.8
Long yearling (18 months of age)	475	1,045	0.35	0.77	19.06	4.33	9.53	0.75	1.65	0.43	0.95	32	22	13.5	7.35	16.2
Two year old (24 months of age)	540	1,188	0.20	0.44	19.26	4.38	9.64	0.74	1.63	0.39	0.86	31	20	13.0	7.40	16.3

[a]Dry matter basis.

TABLE 2A Nutrient Concentrations in Diets for Horses and Ponies Expressed on 100 Percent Dry Matter Basis [a]

	Digestible Energy		Example Diet Proportions: Hay Containing 2.2 Mcal/kg		Example Diet Proportions: Hay Containing 2.0 Mcal/kg		Crude Protein	Calcium	Phosphorus	Vitamin A Activity	
	Mcal/kg	Mcal/lb	Concentrate[b]	Roughage	Concentrate[b]	Roughage	(%)	(%)	(%)	IU/kg	IU/lb
Mature horses and ponies at maintenance	2.2	1.0	0	100	10	95	8.5	0.30	0.20	1,600	725
Mares, last 90 days of gestation	2.5	1.1	25	75	35	65	11.0	0.50	0.35	3,400	1,550
Lactating mare, first 3 months	2.8	1.3	45	55	55	45	14.0	0.50	0.35	2,800	1,275
Lactating mare, 3 months to weanling	2.6	1.2	30	70	40	60	12.0	0.45	0.30	2,450	1,150
Creep feed	3.5	1.6	100	0	100	0	18.0	0.85	0.60		
Foal (3 months of age)	3.25	1.5	75	25	80	20	18.0	0.85	0.60	2,000	900
Weanling (6 months of age)	3.1	1.4	65	35	70	30	16.0	0.70	0.50	2,000	900
Yearling (12 months of age)	2.8	1.3	45	55	55	45	13.5	0.55	0.40	2,000	900
Long yearling (18 months of age)	2.6	1.2	30	70	40	60	11.0	0.45	0.35	2,000	900
Two year old (light training)	2.6	1.3	30	70	40	60	10.0	0.45	0.35	2,000	900
Mature working horses											
(light work[c])	2.5	1.1	25	75	35	65	8.5	0.30	0.20	1,600	725
(moderate work[d])	2.9	1.3	50	50	60	40	8.5	0.30	0.20	1,600	725
(intense work[e])	3.1	1.4	65	35	70	30	8.5	0.30	0.20	1,600	725

[a] Values are rounded to account for differences among Tables 1A–1D and for greater practical application.
[b] Concentrate containing 3.6 Mcal/kg.
[c] Examples are horses used in western pleasure, bridle path hack, equitation, etc.
[d] Examples are ranch work, roping, cutting, barrel racing, jumping, etc.
[e] Examples are race training, polo, etc.

TABLE 2B Nutrient Concentration in Diets for Horses and Ponies Expressed on 90 Percent Dry Matter Basis[a]

	Digestible Energy		Crude Protein	Calcium	Phosphorus	Vitamin A Activity	
	Mcal/kg	Mcal/lb	(%)	(%)	(%)	IU/kg	IU/lb
Mature horses and ponies at maintenance	2.0	0.9	7.7	0.27	0.18	1,450	650
Mares, last 90 days of gestation	2.25	1.0	10.0	0.45	0.30	3,000	1,400
Lactating mare, first 3 months	2.6	1.2	12.5	0.45	0.30	2,500	1,150
Lactating mare, 3 months to weanling	2.3	1.1	11.0	0.40	0.25	2,200	1,000
Creep feed	3.15	1.4	16.0	0.80	0.55		
Foal (3 months of age)	2.9	1.35	16.0	0.80	0.55	1,800	800
Weanling (6 months of age)	2.8	1.25	14.5	0.60	0.45	1,800	800
Yearling (12 months of age)	2.6	1.2	12.0	0.50	0.35	1,800	800
Long yearling (18 months of age)	2.3	1.1	10.0	0.40	0.30	1,800	800
Two year old (light training)	2.6	1.2	9.0	0.40	0.30	1,800	800
Mature working horses							
(light work[b])	2.25	1.0	7.7	0.27	0.18	1,450	650
(moderate work[c])	2.6	1.2	7.7	0.27	0.18	1,450	650
(intense work[d])	2.8	1.25	7.7	0.27	0.18	1,450	650

[a] Values are rounded to account for differences among Tables 1A–1D and for greater practical application.
[b] Examples are horses used in western pleasure, bridle path hack, equitation, etc.
[c] Examples are ranch work, roping, cutting, barrel racing, jumping, etc.
[d] Examples are race training, polo, etc.

TABLE 3 Dietary Minerals and Vitamins for Horses

	Adequate Levels		
	Maintenance of Mature Horses	Growth	Toxic Levels[a]
Calcium	—[b]	—[b]	
Phosphorus	—[b]	—[b]	
Sodium, %	0.35	0.35	
Potassium, %	0.4	0.5	
Magnesium, %	0.09	0.1	
Sulfur, %	0.15	0.15	
Iron, mg/kg	40	50	
Zinc, mg/kg	40	40	9,000
Manganese, mg/kg	40	40	*
Copper, mg/kg	9	9	*
Iodine, mg/kg	0.1	0.1	4.8
Cobalt, mg/kg	0.1	0.1	
Selenium, mg/kg	0.1	0.1	5.0
Fluorine, mg/kg	—	—	50+
Lead, mg/kg	—	—	80
Vitamin A	—[b]	—[b]	*
Vitamin D, IU/kg	275	275	150,000
Vitamin E, mg/kg	15	15	
Thiamin, mg/kg	3	3	
Riboflavin, mg/kg	2.2	2.2	
Pantothenic acid, mg/kg	15	15	

[a] Nutrients known to be toxic to other species but without adequate information on the horse are indicated by *.
[b] See Table 1.

TABLE 4 Abbreviations for Terms Used in Table 6

dehy	dehydrated
extd	extracted
extn	extraction
extn unspecified	extraction unspecified
g	gram
gr	grade
grnd	ground
IU	International Units
kcal	kilocalories
kg	kilogram(s)
lt	less than
mech extd	mechanically extracted, expeller extracted, hydraulic extracted, or old process
μg	microgram
mg	milligram
mt	more than
s-c	sun-cured
solv extd	solvent extracted
spp	species
w	with
wo	without

TABLE 5 Stage of Maturity Terms Used in Table 6

Preferred Term	Definition	Comparable Terms
For Plants That Bloom		
Germinated	Stage in which the embryo in a seed resumes growth after a dormant period	Sprouted
Early vegetative	Stage at which the plant is vegetative and before the stems elongate	Fresh new growth, before heading out, before inflorescence emergence, immature, prebud stage, very immature, young
Late bloom	Stage at which stems are beginning to elongate to just before blooming; first bud to first flowers	Before bloom, bud stage, budding plants, heading to in bloom, heads just showing, jointing and boot (grasses), prebloom, preflowering, stems elongated
Early bloom	Stage between initiation of bloom and stage in which 1/10 of the plants are in bloom; some grass heads are in anthesis	Early anthesis, first flower, headed out, in head, up to 1/10 bloom
Midbloom	Stage in which 1/10 to 2/3 of the plants are in bloom; most grass heads are in anthesis	Bloom, flowering, flowering plants, half-bloom, in bloom, mid anthesis
Full bloom	Stage in which 2/3 or more of the plants are in bloom	Three-fourths to full bloom, late anthesis
Late bloom	Stage in which blossoms begin to dry and fall and seeds begin to form	Fifteen days after silking, before milk, in bloom to early pod, late to past anthesis
Milk stage	Stage in which seeds are well formed but soft and immature	After anthesis, early seed, fruiting, in tassel, late bloom to early seed, past bloom, pod stage, post anthesis, post bloom, seed developing, seed forming, soft, soft immature
Dough stage	Stage in which the seeds are of dough-like consistency	Dough stage, nearly mature, seeds, dough, seeds well developed, soft dent
Mature	Stage in which plants are normally harvested for seed	Dent, dough to glazing, fruiting, fruiting plants, in seed, kernels ripe, ripe seed
Post ripe	Stage that follows maturity; seeds are ripe and plants have been cast and weathering has taken place (applies mostly to range plants)	Late seed, over ripe, very mature
Stem-cured	Stage in which plants are cured on the stem; seeds have been cast and weathering has taken place (applies mostly to range plants)	Dormant, mature and weathered, seeds cast
Regrowth early vegetative	Stage in which regrowth occurs without flowering activity; vegetative crop aftermath; regrowth in stubble (applies primarily to fall regrowth in temperate climates); early dry season regrowth	Vegetative recovery growth

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)

Line No.	SHORT FEED NAME Scientific Name	International Feed Number[a]	Dry Matter (%)	DE (Mcal/kg)	TDN (%)	Crude Protein (%)	Digestible Protein (%)	Lysine (%)	Crude Fiber (%)
	ALFALFA								
	Medicago sativa								
1	grazed, prebloom	2-00-181	21	2.51	57	21.2	15.6	1.06	22
2	grazed, full bloom	2-00-188	25	2.29	52	16.3	11.4	0.65	33
3	hay, s-c, early bloom	1-00-059	90	2.42	55	17.2	13.4	0.94	31
4	hay, s-c, midbloom	1-00-063	89	2.29	52	16.0	11.6	0.90	32
5	hay, s-c, full bloom	1-00-068	89	2.16	49	15.0	10.1	0.64	34
6	meal, dehy, 15% protein	1-00-022	91	2.42	55	16.3	11.8	0.66	33
7	meal, dehy, 17% protein	1-00-023	92	2.46	56	19.7	13.9	0.96	27
	BAHIAGRASS								
	Paspalum notatum								
8	grazed	2-00-464	30	2.11	48	7.9	4.2	—	32
9	hay, s-c	1-00-462	91	1.89	43	5.8	2.5	—	30
	BARLEY								
	Hardeum vulgare								
10	grain	4-00-549	89	3.61	82	13.9	11.4	0.48	6
11	grain, Pacific Coast	4-00-939	90	3.48	79	10.7	7.0	0.35	7
12	hay, s-c	1-00-495	89	1.89	44	8.5	4.7	—	27
13	straw	1-00-498	90	1.63	37	4.0	0.9	—	42
	BEET, SUGAR								
	Beta vulgaris, B.saccharifera								
14	pulp, dehy	4-00-669	91	2.86	65	8.0	5.0	0.66	22
	BERMUDAGRASS								
	Cynodon dactylon								
15	grazed	2-00-712	39	2.20	50	9.1	5.2	—	28
16	hay, s-c	1-00-716	91	1.98	45	7.0	4.2	—	34
	BLUEGRASS, KENTUCKY								
	Pao pratensis								
17	grazed, early	2-00-777	31	2.46	56	17.0	12.4	—	26
18	grazed, posthead	2-00-782	35	2.20	50	11.6	7.4	—	27
19	hay, s-c	1-00-776	90	2.20	50	11.0	5.1	—	30
	BREWERS								
20	grains, dehy	5-02-141	92	2.99	68	27.0	20.9	0.95	16
	BROME								
	Bromus spp								
21	grazed, vegetative	2-00-892	32	3.00	68	18.3	12.6	—	24
22	hay, s-c, late bloom	1-00-888	90	2.38	54	7.4	5.0	—	40
	CANARYGRASS, REED								
	Phalaris arundinacea								
23	grazed	2-01-113	27	2.38	54	12.0	7.5	—	29
24	hay	1-01-104	91	2.16	49	12.3	7.6	—	33
	CITRUS								
25	pulp wo fines, dehy	4-01-237	90	2.99	68	6.9	3.6	—	14
	CLOVER, ALSIKE								
	Trifolium hybridum								
26	hay, s-c	1-01-313	89	2.11	48	14.8	10.1	—	29
	CLOVER, CRIMSON								
	Trifolium incarnatum								
27	grazed	2-01-336	17	2.42	55	17.2	12.1	—	27
28	hay, s-c	1-01-328	89	2.16	49	18.0	13.1	—	32
	CLOVER, LADINO								
	Trifolium repens								
29	hay, s-c	1-01-378	90	2.24	51	21.0	15.6	—	20
	CLOVER, RED								
	Trifolium pratense								
30	grazed, early bloom	2-01-428	20	2.51	57	21.1	12.0	—	19
31	grazed, late bloom	2-01-429	26	2.42	55	14.5	9.8	—	30
32	hay, s-c	1-01-415	89	2.16	49	14.9	10.0	—	30

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)—Continued

Line No.	Cell Walls (%)	ADF (%)	Cellulose (%)	Lignin (%)	Calcium (%)	Copper (mg/kg)	Iron (mg/kg)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Potassium (%)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)
1	—	—	—	—	2.26	10	200	0.25	28	0.35	2.35	0.20	0.50	18
2	—	—	—	—	1.53	9	330	0.27	25	0.27	2.15	0.15	0.31	15
3	48	38	28	10	1.75	15	200	0.30	32	0.26	2.55	0.15	0.29	17
4	50	40	29	11	1.50	13	180	0.29	29	0.25	1.90	0.14	0.28	17
5	52	42	30	12	1.29	12	170	0.31	27	0.24	1.80	0.14	0.26	17
6	51	41	29	12	1.40	11	330	0.30	31	0.24	2.50	0.10	0.20	22
7	45	35	24	11	1.50	10	400	0.39	31	0.26	2.70	0.10	0.26	22
8	—	—	—	—	0.45	—	60	0.25	—	0.19	1.45	—	—	—
9	—	—	—	—	0.45	—	60	0.19	—	0.22	1.45	—	—	—
10	19	7	—	—	0.05	9	90	0.15	19	0.37	0.45	0.03	0.18	17
11	21	9	—	—	0.05	9	80	0.13	18	0.37	0.58	0.02	0.17	17
12	—	—	—	—	0.21	4	300	0.19	39	0.31	1.49	0.14	0.17	—
13	80	59	37	12	0.24	10	300	0.15	17	0.05	2.01	0.14	0.17	—
14	59	34	—	—	0.75	14	330	0.30	38	0.10	0.20	0.23	0.22	10
15	—	—	—	—	0.49	—	—	0.19	—	0.27	—	—	—	—
16	80	35	23	12	0.40	—	—	0.17	—	0.19	1.57	0.44	—	20
17	—	—	—	—	0.56	10	—	0.20	79	0.40	2.20	—	—	—
18	—	—	—	—	0.46	9	—	0.18	68	0.39	2.01	—	—	—
19	—	—	—	—	0.30	9	260	0.16	93	0.29	1.70	0.14	0.13	—
20	42	23	18	5	0.30	24	270	0.17	42	0.58	0.09	0.28	0.34	30
21	60	31	27	4	0.55	5	100	0.18	—	0.35	2.32	0.02	0.20	—
22	72	44	36	8	0.32	7	100	0.13	106	0.22	2.00	0.02	0.20	—
23	—	—	—	—	0.42	9	150	—	—	0.35	3.64	—	—	—
24	—	—	—	—	0.37	9	150	0.31	106	0.25	1.86	0.39	0.41	—
25	23	23	—	—	2.07	6	170	0.16	7	0.13	0.77	0.10	0.07	16
26	—	—	—	—	1.32	6	260	0.41	69	0.29	2.46	0.46	0.17	—
27	—	—	—	—	1.33	—	250	0.29	317	0.32	2.51	0.40	0.28	—
28	—	—	—	—	1.39	—	300	0.29	200	0.20	2.00	0.39	0.28	—
29	36	32	25	7	1.32	9	600	0.29	200	0.24	2.80	0.39	0.18	17
30	—	—	—	—	2.26	—	300	0.51	—	0.38	2.49	0.22	0.17	—
31	—	—	—	—	1.01	—	306	0.43	—	0.27	1.96	0.20	0.17	—
32	56	41	30	10	1.49	11	310	0.45	73	0.25	1.66	0.18	0.17	17

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)—Continued

Line No.	SHORT FEED NAME Scientific Name	International Feed Number[a]	Dry Matter (%)	DE (Mcal/kg)	TDN (%)	Crude Protein (%)	Digestible Protein (%)	Lysine (%)	Crude Fiber (%)
	CORN								
	Zea mays								
33	cobs, ground	1-02-782	90	1.36	31	2.8	0.5	—	36
34	distillers grains, dehy	5-02-842	92	3.08	70	29.8	21.0	0.87	12
35	ears, grnd	4-02-849	87	3.26	74	9.1	5.6	0.20	10
36	grain	4-02-985	88	3.87	88	10.9	8.5	0.30	2
	COTTON								
	Gossypium spp								
37	hulls	1-01-599	91	1.45	33	4.2	1.1	—	50
	FESCUE, MEADOW								
	Festuca elatior								
38	grazed	2-01-920	27	2.29	52	11.5	7.3	—	29
39	hay, s-c	1-01-912	88	2.02	46	10.5	5.8	—	33
	FLAX								
	Linum usitatissimum								
40	seeds, meal, solv extd (Linseed meal)	5-02-048	91	3.04	69	38.9	27.6	1.34	10
	LESPEDEZA								
	L. striata, L. stipulacea								
41	grazed	2-02-568	31	2.20	50	14.9	10.2	—	38
42	hay, s-c	1-08-591	91	2.07	47	13.9	9.3	—	32
	LINSEED—see FLAX								
	MILK								
	Bos taurus								
43	skimmed, dehy	5-01-175	94	4.05	92	36.0	30.3	2.69	0.3
	MOLASSES								
44	beet, sugar, mn 48% invert	4-00-668	78	3.17	72	8.7	5.3	—	—
45	sugarcane, molasses, dehy	4-04-695	94	3.17	72	9.3	5.8	—	5.0
46	sugarcane, molasses, mn 48% invert	4-04-696	75	3.26	74	4.3	2.0	—	—
	OATS								
	Avena sativa								
47	grain	4-03-309	89	3.34	76	13.6	10.5	—	12
48	grain, Pacific Coast	4-07-999	91	3.34	77	10.1	6.5	—	12
49	hay, s-c	1-03-280	90	2.07	47	8.9	5.1	—	32
50	straw	1-03-283	92	2.11	40	4.3	2.5	—	40
	ORCHARDGRASS								
	Dactylis glomerata								
51	grazed	2-03-439	19	2.42	55	18.4	13.2	—	27
52	hay, s-c	1-03-438	89	2.07	47	10.1	6.1	—	36
	PANGOLAGRASS								
	Digitara decumbens								
53	grazed	2-03-493	19	2.24	51	12.5	8.1	—	29
54	hay, s-c	1-09-459	88	1.98	45	9.6	5.7	—	27
	PRAIRIE								
55	midwest, hay, s-c	1-03-191	90	2.02	46	6.7	3.2	—	33
	RYE								
	Secale cereale								
56	grain	4-04-047	88	3.52	80	13.8	9.9	0.48	3
	SORGHUM								
	Sorghum vulgare								
57	grain	4-04-383	90	3.52	80	12.6	8.8	0.28	3
	SOYBEAN								
	Glycine max								
58	hay, s-c	1-04-558	89	2.11	48	15.9	11.0	—	34
59	hulls	1-04-560	92	2.64	60	12.0	7.7	1.61	40
60	seeds	5-04-610	91	4.05	92	43.2	31.7	2.93	6
61	seeds, meal, solv extd	5-04-604	90	3.60	82	50.9	35.7	3.28	7

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)—Continued

Line No.	Cell Walls (%)	ADF (%)	Cellulose (%)	Lignin (%)	Calcium (%)	Copper (mg/kg)	Iron (mg/kg)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Potassium (%)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)
33	89	35	28	7	0.12	7	230	0.07	6	0.04	0.91	—	0.47	—
34	43	—	—	—	0.11	48	200	0.08	20	0.44	0.20	0.10	0.46	35
35	—	—	—	—	0.05	8	80	0.16	6	0.26	0.56	0.05	0.22	18
36	—	—	—	—	0.05	4	30	0.03	6	0.60	0.35	0.01	0.14	21
37	90	71	48	23	0.15	13	150	0.14	10	0.08	0.87	0.02	—	16
38	—	—	—	—	0.60	4	—	0.37	27	0.43	2.34	—	—	—
39	65	43	37	6	0.57	4	—	0.59	24	0.37	1.74	—	—	—
40	-	—	—	—	0.43	28	360	0.67	42	0.90	1.53	0.15	0.44	—
41	—	—	—	—	1.10	—	310	0.29	154	0.28	1.26	0.31	—	—
42	—	—	—	—	1.15	—	330	0.25	184	0.25	1.03	0.30	—	—
43	—	—	—	—	1.30	1	10	0.13	2	1.09	1.66	0.50	0.34	68
44	—	—	—	—	0.21	22	100	0.30	6	0.03	6.20	1.52	0.61	18
45	—	—	—	—	0.87	73	240	0.43	52	0.20	3.68	0.19	0.46	33
46	—	—	—	—	1.05	80	250	0.47	57	0.15	3.80	0.22	0.46	30
47	31	17	14	3	0.07	7	80	0.19	43	0.37	0.44	0.18	0.38	33
48	—	—	—	—	0.11	6	90	0.19	42	0.34	0.44	0.16	0.23	—
49	—	36	30	6	0.30	4	400	0.75	120	0.26	1.23	0.17	0.30	—
50	70	47	34	13	0.25	10	200	0.19	37	0.07	2.37	0.40	0.23	—
51	55	31	28	3	0.57	7	170	0.19	40	0.54	3.27	0.04	0.21	17
52	—	—	—	—	0.35	14	110	0.20	40	0.31	3.01	—	0.26	18
53	—	—	—	—	0.45	—	—	0.14	—	0.35	—	—	—	—
54	—	—	—	—	0.37	—	—	0.13	—	0.23	—	—	—	—
55	—	—	—	—	0.41	23	100	0.28	48	0.15	1.01	0.04	—	—
56	—	—	—	—	0.07	8	70	0.14	62	0.36	0.52	0.03	0.17	36
57	—	—	—	—	0.03	11	50	0.20	17	0.33	0.39	0.03	0.16	16
58	—	—	—	—	1.22	9	290	0.79	101	0.28	1.02	0.09	0.24	24
59	67	46	44	2	0.45	18	320	—	14	0.15	1.03	0.05	—	24
60	—	—	—	—	0.28	17	90	0.31	32	0.66	1.77	0.13	0.24	18
61	14	10	8	2	0.31	30	130	0.30	32	0.70	2.19	0.31	0.48	48

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)—Continued

Line No.	SHORT FEED NAME Scientific Name	International Feed Number[a]	Dry Matter (%)	DE (Mcal/kg)	TDN (%)	Crude Protein (%)	Digestible Protein (%)	Lysine (%)	Crude Fiber (%)
	SUNFLOWER								
	Helianthus spp								
62	seeds wo hulls, meal, solv extd	5-04-739	92	3.12	71	50.3	—	1.85	12
	TIMOTHY								
	Phleum pratense								
63	grazed, midbloom	2-04-905	30	2.15	49	9.6	5.2	—	31
64	hay, s-c, pre-head	1-04-881	89	2.20	50	11.5	7.2	—	31
65	hay, s-c, head	1-04-883	88	1.98	45	9.0	4.8	—	32
	TREFOIL, BIRDSFOOT								
	Lotus corniculatus								
66	hay, s-c	1-05-044	91	2.20	50	16.0	12.5	—	30
	WHEAT								
	Triticum spp								
67	bran	4-05-190	89	2.94	67	17.0	14.4	0.68	11
68	grain, hard red winter	4-05-268	89	3.83	87	14.4	10.7	0.42	3
69	grain, soft red winter	4-05-294	89	3.83	87	13.0	9.2	0.57	3
70	grain, soft white winter	4-05-337	89	3.83	87	11.5	7.5	0.35	3
71	hay, s-c	1-05-172	89	1.89	43	8.7	4.9	—	29
72	straw	1-05-175	89	1.50	34	4.2	1.0	—	41
	YEAST								
	Saccharomyces cerevisiae								
73	brewer's, dehy	7-05-527	93	3.30	75	48.3	32.8	3.33	3

TABLE 7 Mineral Supplements

	Calcium (%)	Phosphorus (%)	Magnesium (%)
Bone meal, steamed	32.3	13.3	0.6
Calcium carbonate	36.7	0.5	0.3
Dicalcium phosphate	23.7	18.8	—
Limestone, ground	36.1	—	2.1
Monosodium phosphate	—	25.8	—
Monodicalcium phosphate	16.8	22.1	0.5
Phosphate, defluorinated	31.7	13.7	0.3
Sodium tripolyphosphate	—	25.1	—

TABLE 6 Composition of Feeds Commonly Used in Horse Diets—Dry Basis (Moisture Free)—Continued

Line No.	Cell Walls (%)	ADF (%)	Cellulose (%)	Lignin (%)	Calcium (%)	Copper (mg/kg)	Iron (mg/kg)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Potassium (%)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)
62	—	—	—	—	0.41	4	40	0.81	25	1.10	1.10	0.44	—	—
63	—	—	—	—	0.28	11	200	0.15	190	0.25	2.40	0.19	0.13	—
64	64	37	33	4	0.50	6	200	0.15	—	0.25	1.92	0.18	0.13	—
65	70	45	34	11	0.41	5	140	0.16	46	0.19	1.60	0.18	0.13	—
66	44	34	25	9	1.75	9	230	0.51	15	0.22	1.80	0.18	—	77
67	45	12	8	4	0.12	14	190	0.59	130	1.43	1.60	0.04	0.25	120
68	40	—	—	—	0.05	5	40	0.17	44	0.48	0.45	0.03	0.18	43
69	30	—	—	—	0.05	7	30	0.11	36	0.46	0.46	0.02	0.12	48
70	14	4	—	—	0.05	8	40	0.11	40	0.45	0.41	0.02	0.13	30
71	68	41	—	—	0.15	—	200	0.12	40	0.19	1.00	0.28	0.24	—
72	85	54	39	15	0.21	3	200	0.12	40	0.08	1.10	0.14	0.19	—
73	—	—	—	—	0.5	36	100	0.25	6	1.52	1.86	0.08	0.41	42

TABLE 8 Vitamin Content

	International Feed Numbers	Carotene (mg/kg)	Riboflavin (mg/kg)	Thiamin (mg/kg)	Vitamin E (mg/kg)
Alfalfa hay, midbloom	1-00-063	26.1	10.6	3.0	90.0
Alfalfa meal, 17% protein	1-00-023	131.1	14.4	3.7	134.8
Barley, grain	4-00-549	1.0	1.8	5.0	18.0
Brewers' grains	5-02-141	—	1.4	0.6	28.1
Clover hay, ladino	1-01-378	20.0	15.0	4.2	70.0
Clover hay, red, sun-cured	1-01-115	19.8	17.8	2.2	60.0
Corn, grain	4-02-935	2.5	1.5	2.3	25.7
Linseed meal	5-02-048	—	3.1	8.6	18.0
Oats, grain	4-03-309	0.1	1.7	7.2	18.5
Oat hay, sun-cured	1-03-280	15.0	5.3	3.3	12.5
Rye, grain	4-04-383	1.0	1.8	3.4	17.2
Skimmed milk, dehydrated	5-01-175	—	20.4	4.0	10.0
Soybean meal	5-04-604	0.2	3.3	6.2	2.3
Timothy hay, sun-cured	1-04-893	9.0	12.4	1.7	63.1
Wheat bran	4-05-190	2.9	5.4	7.3	13.4
Brewer's yeast	7-05-527	—	39.2	100.0	2.4

TABLE 9 Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by	Units Given	Units Wanted	For Conversion Multiply by
lb	g	453.6	μg/kg	μg/lb	0.4536
lb	kg	0.4536	Mcal	kcal	1,000.
oz	g	28.35	kcal/kg	kcal/lb	0.4536
kg	lb	2.2046	kcal/lb	kcal/kg	2.2046
kg	mg	1,000,000.	ppm	μg/g	1.
kg	g	1,000.	ppm	mg/kg	1.
g	mg	1,000.	ppm	mg/lb	0.4536
g	μg	1,000,000.	mg/kg	%	0.0001
mg	μg	1,000.	ppm	%	0.0001
mg/g	mg/lb	453.6	mg/g	%	0.1
mg/kg	mg/lb	0.4536	g/kg	%	0.1

TABLE 10 Weight Equivalents

1 lb = 453.6 g = 0.4536 kg = 16 oz
1 oz = 28.35 g
1 kg = 1,000 g = 2.2046 lb
1 g = 1,000 mg
1 mg = 1,000 μg = 0.001 g
1 μg = 0.001 mg = 0.000001 g
1 μg per g or 1 mg per kg is the same as ppm

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