Evaluating Rations for Horses

David W. Freeman
OSU Extension Equine Specialist

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Introduction

Horses are fed a variety of feeds. Diets range from 100 percent pasture forage to 100 percent completely processed mixes. Most horses are fed forage in the form of hay or pasture in combination with a grain mix. The choice of feed is influenced by the horses' requirements, availability of pasture, availability and cost of commercially prepared feeds, feedstuffs traditionally fed, and how the horses are used and managed. Nutrients should be supplied in the amount, form, and method that safely and efficiently meet requirements. Correctly supplying nutrition to horses requires knowledge of requirements, feeds, and nutritional management.

Most horse owners rely on formulated feeds from commercial sources, or on a nutritionist's support for customer formula mixes. Even so, in order to make accurate decisions, horse owners should have a general knowledge of nutrients, how nutrient needs change with different production and use classes of horses, and how to determine if nutrient supply is aligned with requirements. This fact sheet provides information on feeds and ration evaluation for horses. Extension Fact Sheet ANSI-3997 provides information on nutrients and requirements for horses of different size, age, and production state.

Feedstuffs

Feeds for horses can be divided into forage, grain and grain by-product, and supplement categories. Tables 1 through 3 provide average nutrient concentrations of different feedstuffs. Feeds displayed are not intended to represent ideal ingredients. The tables are intended to show how nutrient content of

Table 1. Example Energy, Protein, and Mineral Content of Forages.[a]

Forage	*Dry Matter (%)*	*Digestible Energy (Mcal/lb DM)*	*Crude Protein (% DM)*	*Calcium (% DM)*	*Phosphorus (% DM)*
Bermudagrass hay	87	0.9	13	0.4	0.2
Legume hay	84	1.2	20	1.5	0.3
Grass pasture, Cool season	20	1.1	26	0.6	0.4

[a]Nutrient content will vary between different sources of the same feedstuff. Nutrient content can be estimated by using feed tables or through nutrient tests.

Table 2. Example Energy, Protein, and Mineral Content of Grains and Grain By-Products.[a]

Grain	*Dry Matter (%)*	*Digestible Energy (Mcal/lb DM)*	*Crude Protein (% DM)*	*Calcium (% DM)*	*Phosphorus (% DM)*
Corn	88	1.8	9.4	0.04	0.30
Oats	89	1.5	13.6	0.07	0.30
Soybean Hulls	90	1.0	13.9	0.63	0.17
Wheat midds	89	1.5	18.5	0.16	1.02

[a]Nutrient content will vary between different sources of the same feedstuff. Nutrient content can be estimated by using feed tables or through nutrient tests.

Table 3. Example Energy, Protein, and Mineral Content of Two High Protein Feeds.[a]

Grain	*Dry Matter* (%)	*Digestible Energy* (Mcal/lb DM)	*Crude Protein* (% DM)	*Lysine* (% DM)	*Calcium* (% DM)	*Phosphorus* (% DM)
Soybean meal	89	1.7	54	3.4	0.35	0.70
Cottonseed meal	91	1.4	45	1.8	0.20	1.15

[a]Nutrient content will vary between different sources of the same feedstuff. Nutrient content can be estimated by using feed tables or through nutrient tests.

different feeds vary. The nutrient content of feedstuffs can be estimated from values reported in feed databases and nutrition texts. Values listed in feed tables are averages. Some feedstuffs are highly variable in nutrient content from source to source, so averages may be of limited value. Accuracy of feed tables will increase when the values represent large numbers of samples on feedstuffs with low variability from source to source.

Feedstuffs can be analyzed for nutrient content at feed testing labs. Testing feedstuffs will be of greater value for large amounts of a feed that will be fed for a long period of time such as a yearly hay supply. Proper sampling techniques of feeds that are to be tested will increase accuracy of test results, especially with forages. Information on feed testing laboratories and sampling techniques can be obtained with the assistance of local Cooperative Extension professionals.

Forages

Forages are long stem, high fiber feedstuffs. Forages include growing plants and plants that are harvested and processed into hay, haylage and hay cubes. Compared with grains, forages generally contain lower concentrations of digestible energy, higher levels of fibrous carbohydrates and lower levels of nonfibrous carbohydrates. Nutrient content will vary between forage types and stages of growth.

Legumes, such as alfalfa, will contain larger concentrations of protein than grass species, and generally will have a digestible energy value of 10 percent to 20 percent more than a grass in the same growth stage. Legumes also will contain higher levels of some minerals and vitamins. Improved grass species such as bermudagrass, bluestem, and cool season species like wheat, rye, and ryegrass will typically contain more nutrients per weight than native prairie grasses. Nutrient levels of pastures and hays identified as prairie and native grass will vary greatly because of the many different grasses that may be represented.

Grains and Grain By-products

Grains are seeds harvested from plants. Grain by-products are portions remaining after the removal of certain parts of the grain, i.e. the removal of sugar and starch from the grain kernel. Typically, grains are higher in starch and lower in fiber than forages. Barley, oats, corn, and milo are four commonly fed grains. The starch, fiber, protein, mineral, and vitamin content of by-products vary greatly. Wheat midds, rice bran, distiller's grains, beet pulp, and soybean hulls are by-products that are commonly used as portions of grain mixes. Other by-products, such as soybean meal, are high protein feeds and are used as supplements in grain mixes to increase the protein value of a mix. Feeding of grains and grain by-products with significant digestible energy values must be regulated as over consumption leads to digestive upset (See Extension Fact Sheet ANSI-3973 Feeding Management of the Equine).

Supplements

Supplements are added to rations to balance specific nutrients or to raise levels of certain substances. Premixes are routinely added to increase protein, mineral and vitamin amounts. Vegetable oil may be added to increase the fatty acid content and to raise the energy concentration. Other ingredients may not have as direct an effect on nutrient balance. These compounds are termed additives, and may include compounds with reported health benefits outside of what is known as the nutritional requirements for horses.

Commercially Prepared Feeds

Commercially prepared horse feeds typically contain a mixture of grains, grain by-products, high fiber feedstuffs, high protein feeds, minerals, vitamins, and additives. Most are designed to be fed in combination with forage and will indicate such on the feed bag. Others are tagged as complete feeds, which are formulated to be fed solely without need for daily intake of forage. Feeds may be formulated to best be fed to specific classes of horses, i.e. mixes formulated to be fed to growing horses may have more protein and minerals per weight of feed than mixes intended to be fed to mature, nonproducing horses.

Commercially prepared grain mixes will have a feed tag that contains a list of ingredients and the guaranteed levels of certain nutrients contained within the feed. Nutrient levels are expressed as concentrations in the ration, i.e. minimum percent crude protein. If a feed is tagged as 14 percent crude protein, each pound of feed will contain a minimum of 0.14 pounds of crude protein. The list of feed ingredients will provide additional evidence of other nutrients, such as minerals, vitamins and additives not included in the guaranteed analysis of nutrient content. For more information on feed tags see Extension Fact Sheet ANSI-3919 "Feed Tag Information for Commercial Feeds for Horses."

Evaluating Rations

In order to evaluate how well feeds align with requirements, one must have estimates of the horse's nutrient requirement, and the intake and nutrient content of all the feeds in the diet. Estimates of requirements can be found in textbooks and reports that base values on nutritional research (See Extension Fact Sheet ANSI-3997 "Nutrient Needs of Horses"). In practice, energy needs are estimated by feeding levels that maintain horses in appropriate fat cover. Body condition scoring systems are used to index fat cover (See Extension Fact Sheet ANSI-3920 "Body Condition of Horses").

Estimating the intake of a meal-fed diet is fairly simple if there is access to a scale designed to measure weights typical of a rationed diet. Estimating intake from a standard volume, e.g. feed scoop or coffee can, is unreliable. Feeds vary in density because of processing and ingredients. Intake of free choice hay can be estimated by observing disappearance over several days, and making the assumption that intake is similar between horses when group fed. Estimating intake of pasture is more difficult, as daily voluntary intake of feed varies with horses, feedstuffs offered and environmental conditions.

When forage is unlimited, voluntary dry matter intake is expected to range from less than 1.5 percent to greater than 3.0 percent of body weight per day. Higher intakes are expected when young, growing plants are available. Nutrients in young, growing plants will also be more digestible. Intake and nutrient digestibility also will vary between plant types. In general, plants with higher levels of digestible fiber will be more readily consumed as compared to forages high in cellulose and lignin.

Horses can easily become undernourished when the only source of nutrition is pastures with small supply of forage or that contain only forages that are indigestible (See Extension Fact Sheet ANSI-3927 "Refeeding the Poorly Conditioned

Horse"). Conversely, diets containing energy dense grains or access to lush pastures should be regulated by rationing harvested feeds and access to grazing (See Extension Fact Sheets ANSI-3973 "Feeding Management of the Equine" and ANSI-3921 "Understanding Colic in Horses"). Overeating leads to excessively fat body condition and increased incidence of colic and founder.

Generally, diets are formulated to meet energy demands when fed at levels around 70 percent to 85 percent of the expected maximum daily dry matter voluntary intake, resulting in *as fed* dietary intake of grain and hay diets of 2.5 percent to 3.0 percent of body weight per day. Growing horses may consume more as a percent of body weight than mature horses. Diets with feedstuffs low in digestible energy will be fed in larger amounts as compared with diets with higher digestible energy value. Diets formulated for horses with elevated energy needs such as lactating mares and heavily exercising horses will be more energy dense than maintenance diets. Diets with high moisture content such as immature, small grain forage will be consumed at larger amounts because of the high percentage of water associated with the forage intake.

Routine Mathematical Conversions

To be complete, ration evaluation requires knowledge of horse physiology, feedstuffs, and feeding plans. Horse owners are cautioned that mathematical evaluations alone do not account for what can be safely fed under different feeding systems. Nonetheless, there are several routine evaluations that can be conducted in order to check the alignment of the diet with requirements.

The amount of dietary intake and the nutrient densities of that intake should be expressed in the same units, i.e. a *dry matter* or *as fed* basis. When expressed *as fed*, the nutrient densities are representative of feed that contains normally occurring environmental moisture levels. Feed tags provide a guaranteed analysis on an *as fed* basis. If a tag lists crude protein at 12 percent, each pound of feed that is fed will provide 0.12 pounds of protein.

Nutrient densities are expressed on a *dry matter* basis when the normally occurring environmental moisture of a feed is removed by drying in forced air ovens. Nutrient analyses from testing laboratories may express nutrient densities on a *dry matter* basis. Providing analyses on a *dry matter* basis allows for a more accurate compilation of estimates than *as fed* because it removes the influence of differing moisture levels between samples.

Most feed analysis reports provide a percent moisture and percent dry matter of the tested sample and will list results on an *as sampled* and *dry matter* basis. The *as sampled* values can be assumed to be the same *as fed* if the sample is fresh and contains similar moisture levels as what is fed. The percent moisture and percent dry matter of a feed equals 100 percent. Ten pounds of a feed *as fed* that contains 5 percent moisture equals 9.5 pounds of feed on a dry matter basis (10 lbs as fed X 95 percent dry matter). Because water is removed, the nutrient densities of a dried feed will be larger than the corresponding nutrient density on an *as fed* basis. Ten pounds of feed containing one pound of protein *as fed* equals an *as fed* protein density of 10 percent (One pound of protein divided by ten pounds of feed). If that feed contains 10 percent moisture, the protein density on a *dry matter* basis of feed would be 11 percent (One pound of protein divided by nine pounds of dried feed).

To convert nutrient densities from a *dry matter* to *as fed basis*, multiple the nutrient percentage as listed on a dry matter basis by the percent dry matter of the feed. For example, a feed analyzed to contain 0.7 percent calcium on a *dry matter* basis that is 95 percent dry matter would contain 0.66 percent calcium on an *as fed* basis (0.7 X 0.95). To convert a nutrient density value expressed *as fed* to a *dry matter* basis, divide the as fed value by the percent dry matter. For example, a feed analyzed to contain 12 percent crude protein as fed with a dry matter estimate of 90 percent would contain 13.3 percent crude protein on a dry matter basis (12 ÷ 0.90).

The other check involves standardizing units of weight. It is common for nutrient requirements to be expressed in metric units, i.e. grams, and measurements of amounts fed to be in U.S. measurements, i.e. pounds. There are 454 grams in a pound. If nutrient requirements are provided in metric units, the easiest conversion may be to convert pounds fed to grams. Then, the amounts can be multiplied by the percentage of nutrient of interest and compared to the requirements.

Another frequently needed conversion is to convert a nutrient density expressed as a *percent* to *parts per million (ppm)*, or vice versa. Units expressed as *percent* are converted to *ppm* by multiplying the percent of nutrient in decimal form by 10,000. To convert a nutrient density expressed as *ppm* to *percent* in decimal form, multiply the *ppm* by 0.0001. An ingredient listed as 4 percent of the diet equals 400 ppm (.04 X 10,000). Four hundred ppm equals 4 percent (400 X 0.0001).

Example One: As Fed verses Dry Matter

As mentioned previously, feed test results are provided on a dry matter basis so to remove the variability of water content from different batches of the same feedstuff or mix. Feedstuffs contain a certain amount of moisture on an as fed basis, so the amount fed can be split into moisture and dry matter. Incorrect results will be obtained if calculations indiscriminately combine amounts on an as fed basis with nutrient analyses expressed on a dry matter basis.

A. A feed test report lists crude protein percentage on a dry matter basis at 11.4%, and moisture content at 8%. What would the percent crude protein be on an as fed basis?

Convert the percentage listed on a dry matter basis to as fed. (If the mix is 8% moisture as fed, it would contain 92% dry matter as fed). Then, multiply percentage of crude protein by amount fed to obtain the amount of crude protein fed per day.

11.4% crude protein dry matter basis X .92 = 10.5% crude protein as fed basis.

(0.114 crude protein/feed dry matter X 0.92 dry matter/feed as fed = 0.105 crude protein/ feed as fed)

B. A feed tag lists calcium percent of a mix at 0.7% on an as fed basis. How many grams of calcium does each pound of the mix contain on an as fed basis?

Calculate the amount by multiplying a pound by the percent contained, remembering to convert the percentage to the proper decimal place before multiplying. Then, multiply the amount by 454 grams/pound to obtain the amount expressed as grams.

1 lb X 0.007 = .007 lb of calcium/lb of as fed mix X 454 grams/lb = 3.2 grams of calcium per pound of as fed mix.

How many grams of calcium, on a dry matter basis, does each pound of the mix contain if it contains 10% water and 3.2 grams of calcium per pound as fed?

If the mix is 10% moisture, 90% of the mix is dry matter. The amount of calcium per pound of dry matter would be greater than the amount on an as fed basis because water would be removed as a percentage of the total weight of the mix. To convert the amount of calcium per pound of as fed mix to pound of dry matter mix, divide the amount by the percentage of dry matter.

3.2 grams of calcium per pound of as fed mix ÷ 0.90 lb of dry matter per pound of as fed mix = 3.5 grams of calcium per pound of dry matter mix.

The same value could be obtained by knowing the percentage of calcium on an as fed basis.

0.7% calcium on an as fed basis ÷ .90 dry matter = 0.78% calcium on a dry matter basis

1 lb X 0.0078 = .0078 lb of calcium/lb of dry matter mix X 454 grams/lb = 3.5 grams of calcium per pound of dry matter mix.

Example Two: Comparing What is Fed with Estimated Requirements

Compare the dietary intake of crude protein, calcium and phosphorus in Table 4 with estimated requirements for crude protein, calcium, and phosphorus of 500, 20, and 15 grams, respectively. The horse is fed 10 pounds of hay each day with 5 pounds of the grain mix. Are the estimated requirements for crude protein, calcium, and phosphorus aligned with the requirements?

The nutrient content listed in Table 4 is on an as fed basis, as are the amounts of feed, so no conversions between dry matter and as fed basis are necessary. Ten pounds of hay would equate to 4540 grams of hay, and 5 pounds of grain equates to 2270 grams of grain (5 lb X 454 grams/lb). Add the amount of hay crude protein to the amount of grain crude protein to determine the amount of crude protein fed per day. The amount of hay crude protein is determined by multiplying the amount of hay by the percent protein:

Amount of crude protein supplied by hay = 4540 grams of hay fed X 8 percent crude protein = 363 grams of crude protein.

Amount of crude protein supplied by grain mix = 2270 grams of grain fed X 10 percent crude protein = 227 grams of crude protein.

Total ration crude protein = 363 + 227 = 590 grams, which compares to the estimated minimum requirement of 500.

Completing similar exercises for calcium and phosphorus provides estimated intakes of about 25 grams of calcium and 18 grams of phosphorus. So, fed levels of crude protein, calcium, and phosphorus are at or slightly above the estimates for requirements.

Example Three: Altering the Nutrient Densities when Combining Feeds

For the second example, determine the change in nutrient density of a ration when 5 pounds of a grain mix are fed with 7 pounds of oats (Table 5). Also, determine the amount of each nutrient that is fed in the final mix.

To obtain the nutrient densities of the combined grain mix and oats, first determine the relative percentage that each feedstuff supplies to the total. The total amount as fed is 12 pounds. The grain mix makes up 42 percent (5 lbs ÷ 12 lbs) and the oats 58 percent (7 lbs ÷ 12 lbs) of the final mix. Then, multiple the percentage contribution of each feedstuff by the nutrient density of that feedstuff and add the percentages together.

Crude protein percentage of the final mix = (0.42 grain mix X 10% crude protein) + (0.58 oats X 11.5% crude protein) = 4.2% + 6.7% = 10.9%

Calcium percentage of the final mix = (0.42 X 0.5%) + (0.58 X 0.1%) = 0.27%

Phosphorus percentage of the final mix = (0.42 X 0.4%) + (0.58 X 0.4%) = 0.4%

Amount of crude protein fed = 12 pounds X 10.9% = 1.3 pounds

Amount of calcium fed = 12 pounds X 0.27% = 0.0324 pound = 14.7 grams

Amount of phosphorus fed = 12 pounds X 0.4% = 0.048 pounds = 21.8 grams

Adding oats did not alter the crude protein percentage or phosphorus percentage to any significant amount. However, the percent calcium was altered more. The combination of feeds resulted in more phosphorus than calcium being fed, possibly so much that an imbalance of calcium and phosphorus would occur in the total diet. Extension Current Report CR-3969, "The Effects of Adding Grain and Supplements to Commercially Available Grain Mixes for Horses" has expanded examples of combining feedstuffs with formulated feeds.

Table 4. Nutrient Content of Grain Mix and Hay (as fed basis) for Example One.

Feedstuff	*Dry Matter (%)*	*Crude Protein (%)*	*Calcium (%)*	*Phosphorus (%)*
Grain mix	90	10	0.5	0.4
Hay	90	8	0.3	0.2

Table 5. Nutrient Content of Sample Grain Mix and Oats (as fed basis) for Example Two.

Feedstuff	*Dry Matter (%)*	*Crude Protein (%)*	*Calcium (%)*	*Phosphorus (%)*
Grain mix	90	10	0.5	0.4
Oats	90	11.5	0.1	0.4

Example Four: Topdressing Supplements

Many horse owners supplement rations with vitamin or mineral supplements. The third example provides a method for determining the need for vitamins E and D. Vitamin amounts are usually listed as International Units, abbreviated as IU.

In this example, the horse's requirement is estimated at 800 IU of vitamin E per day. The horse is receiving 15 pounds of hay estimated to contain 11.6 IU vitamin E per kilogram as fed, and 4.5 pounds of a grain containing 160 IU vitamin E per kilogram as fed. The first step is to standardize the weights fed with the listed concentrations. A pound is equivalent to 0.454 kg, so multiply the amounts in pounds by 0.454 to obtain equivalent weights in kilograms. Fifteen pounds is about 7 kg, and 4.5 pounds about 2 kg.

Base ration Vitamin E intake:
Hay: 7 kg x 11.6 IU/kg = 81.2 IU/day
Grain: 2 kg x 160 IU/kg = 320 IU/day
Total vitamin E intake: 81.2 IU + 320 IU = 401.2 IU/day

Supplemental vitamin E required:
Daily vitamin E requirement: 800 IU/day
Base ration vitamin E intake: 401 IU/day
Supplemental vitamin E required: 399 IU/day

The actual amount of supplement needed to supply the vitamin E will depend upon the vitamin supplement because vitamin concentrations of supplements vary considerably. If the label on the selected supplement states that it contains 6,400 IU vitamin E/lb of supplement, then 0.0625 lbs/day or 28.4 grams of supplement is required to provide the vitamin E difference of 399 IU/day. This amount was calculated as follows:

399 IU supplemental vitamin E required per day ÷ by 6,400 IU vitamin E/lb of supplement = 0.0625 lb x 454 grams/lb = 28.4 grams/day.

The supplement may also provide other nutrients aside from the one targeted for supplementation. The intake of other nutrients should be calculated in order to avoid over supplementation. In this example, the supplement also provides 800 IU vitamin D/lb, which is equivalent to 1,760 IU/kg. Therefore, 28.4 grams of the supplement provides 50 IU/day of vitamin D (1,760 IU Vitamin D/kg x .0284 kg/day = 50 IU/day of vitamin D). The vitamin D requirements are estimated at 3,300 IU/day.

The hay was estimated to contain essentially no vitamin D. The grain mix label indicates a vitamin D concentration of 1,700 IU vitamin D/kg *as fed*. Therefore, 2 kg of the grain mix provides 3,400 IU of vitamin D/day. The total vitamin D intake, vitamin supplement plus grain mix plus hay, is 3,450 IU/day (50 IU + 3,400 IU + 0 IU = 3,450 IU/day). In this example, topdressing with the vitamin supplement adequately provided needs for vitamins A and D.

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