Rations for Horses: Nutrients, Feedstuffs and Safety

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Ask a group of horse owners the question, 'Why do you feed your horse the feedstuffs you feed?' You will receive a range of answers. Cost, availability and what has been fed traditionally will make up a significant portion of the answers. Although not stated as often, marketing also greatly influences our decisions on feed purchases. The primary purpose of feeding certain feedstuffs is to supply proper nutrition. The intent of this fact sheet is to identify the nutritional basis for decision making for feed selection, specifically safely meeting nutrient needs and following feeding practices that aid digestion.

Meeting Nutrient Needs

Feedstuffs supply nutrients. Nutrients are substances needed for life which must be taken in from the environment. Ration balancing means that requirements have been estimated and intake of nutrients have been arranged to meet estimated nutrient requirements. In general, nutrients are classified into energy, protein, minerals, vitamins and water. Energy is not actually a particular nutrient; rather feedstuffs contain compounds that supply energy. Requirements for nutrients are on a nutrient weight needed per day (i.e. pounds of crude protein per day). When balanced, a ration will contain certain concentrations of nutrients, usually percent of the feed weight (e.g. percent crude protein). These percentages are based on supplying the needed amount of nutrient with an assumed level of feed intake.

Nutrients not only have to be provided in a ration, the nutrients have to be digested and absorbed into the horse's body. The horse can digest all types of nutrients; however, the digestive efficiency is quite variable and influenced by amounts fed and structure of compounds in the feed. For example, energy or protein in hay can range from highly digestible (e.g. 60 percent to 70 percent), to extremely indigestible (e.g. 30 percent to 40 percent). Differences in digestibility within particular forage are largely a function of maturity, as digestibility typically will decrease with plant growth. Differences in digestibility between forage species is largely a function of leaf to stem ratios as increases in leaf content typically will increase digestibility. Most grains are highly digestible (70 percent to 80 percent), and some compounds such as plant oils are near 100 percent digested at levels typically contained in horse diets.

Energy

Energy needs are quantified into Megacalories of digestible energy (Mcal DE). Megacalories are 1,000 Calories, which are the units of measure used in human nutrition. Digestible energy needs are higher with larger body size, growth and production states such as lactation, pregnancy, and exercise (Tables 1 through 3). Feed tags do not provide guarantees for energy concentration because of variability in energetic compounds and digestion efficiency of different feedstuffs by different animals. However, general estimates for digestible energy concentration of commonly fed feedstuffs are available from calculations based on compounds contained in the feedstuff and research trials. High energy grain mixes intended to be fed with forage are usually formulated to contain between 1.3 to 1.6 Mcal DE/lb of feed. On the other end of the spectrum, grass hays may contain as little as half that concentration of DE.

Most horse rations are developed with expected intakes on an as fed basis of 2.25 percent to 2.5 percent of body weight per day. This level is below the expected daily voluntary intake of 2.75 percent to 3 percent per day for horses consuming an all hay diet. Designing ration intakes lower than 2 percent to 2.5 percent of body weight per day would require meal feeding of high energy compounds, which as discussed in the following section on safety, might increase incidence of digestive disturbance. These intakes are suggested for harvested feeds, which have consistent and relatively narrow ranges of water content. When horses are consuming all forage diets of immature growing forage, intakes may be much higher because of the large amount of water contained in the forage on an as fed basis.

Table 1. Comparisons of Daily Energy, Protein and Mineral Requirements for Sedentary, Mature Horses of Different Body Weight[a]

Size of Horse	*Digestible Energy (Mcal/day)[b]*	*Crude Protein (lbs)*	*Calcium (grams)*	*Phosphorus (grams)*
Maintenance (1,000 lb)	15	1.2	18	13
Maintenance (1,100 lb)	16.5	1.4	20	14
Maintenance (1,200 lb)	18	1.5	22	15

[a] Nutrient requirements are estimated from the National Research Council's Recommendations for Nutrient Requirements of Horses 2007.
[b] Mcal is Megacalories (1000 Calories), a unit of energy potential.

Table 2. Comparisons of Daily Energy, Protein and Mineral Requirements for Different Production Stages (1100 pounds)[a]

Class of Horse	*Digestible Energy (Mcal/day)[b]*	*Crude Protein (lbs)*	*Calcium (grams)*	*Phosphorus (grams)*
Breeding Stallion	22	1.7	20	14
Broodmare				
Early pregnancy	17	1.4	20	14
8 months pregnancy	18.5	1.7	28	20
11 months pregnancy	21	2.0	36	26
Lactation (1st month)	32	3.4	59	38
Lactation (3rd month)	31	3.2	56	36
Lactation (5th month)	28	2.9	40	25
Working Horse				
Light exercise	20	1.5	30	18
Moderate Exercise	23	1.7	35	21
Heavy Exercise	27	1.9	40	29

[a] Nutrient requirements are estimated from the National Research Council's Recommendations for Nutrient Requirements of Horses 2007.
[b] Mcal is Megacalories (1,000 Calories), a unit of energy potential.

Table 3. Comparisons of Daily Energy, Protein and Mineral Requirements for Growth (Mature weight of 1,100 pounds)[a]

Age of Horse (Weight/growth)	*Digestible Energy (Mcal/day)[b]*	*Crude Protein (lbs)*	*Calcium (grams)*	*Phosphorus (grams)*
6 months:				
475 lb/2 lb/day	15.5	1.5	39	22
12 months:				
700 lb/1 lb.day	19	1.8	38	21
24 months:				
940 lb/0.4 lb/d	19	1.7	37	20

[a] Nutrient requirements are estimated from the National Research Council's Recommendations for Nutrient Requirements of Horses 2007.
[b] Mcal is Megacalories (1,000 Calories), a unit of energy potential.

A mature, 1,100-pound horse consuming 25 pounds of ration per day, estimated to need 17 Mcal DE/day, would require the ration (daily allotment of feed from all sources) to contain about 0.7 Mcal/lb on an as fed basis. Based on the energy content of commonly fed hays and pastures, this horse could consume an all forage diet and meet energy needs for maintenance. However, energy requirements can increase 80 percent or more if the same horse is producing milk. The same ration would have to contain 1.2 Mcal/lb if 30 Mcal DE are needed per day to maintain the body and produce milk. As such, grain would need to be included in the ration unless very high energy dense forage is fed at maximum intakes. Otherwise, decreases in body weight and milk production would be expected. Heightened requirements for production and growth generally require a shift to a larger portion of the ration supplied as grain as well as increases in total amounts of ration fed per day.

Protein

Protein needs are a function of how much protein tissue the horse is building, verses how much it loses to naturally occurring breakdown and losses from the body. The bigger the horse, the larger are the needs to replace naturally occurring losses. Growing horses will need more protein per day in relation to body size as compared with needs when fully grown. For example, a mature, nonproducing 1,100-pound horse is estimated to need 1.4 pounds of dietary crude protein per day. The same horse would have needed 1.8 pounds of crude protein per day when growing. Diets for growing horses will need to be more concentrated in crude protein because needs are larger and expected intake is less than when mature. For example, a mature horse consuming 25 pounds of feed per day can easily meet its crude protein needs with a ration containing as little as 6 percent crude protein ration. The same horse as a 700-pound yearling might only consume 16 pounds to 18 pounds of total ration per day which would relate to needing an 11 percent to 12 percent crude protein diet. As grass hays may contain around 8 percent crude protein, the crude protein needs for the mature horse may be met with an all grass hay diet. The growing horse would need some type of protein supplement such as addition of grain with more protein per pound of feed.

Ideally, estimated needs for protein should be expressed as digestible protein instead of crude protein. Crude protein is simply the amount found in the feedstuff. Unfortunately, requirement estimates have not been refined sufficiently to be expressed on a digestible protein basis. Estimates for crude protein needs assume about an 80 percent digestibility even though digestibility likely varies similarly to energy estimates.

The actual need for protein is for amino acids. Some of the needed amino acids cannot be made by the horse's body. It is essential that these amino acids be supplied in the diet. Protein quality, a term used to relate essential amino acid profiles in feed to dietary needs, is especially important in rations fed to growing horses as they use large amounts of essential amino acids to build lean tissue. Lysine is the most limiting essential amino acid, which means it is the essential amino acid needed in largest amounts. The routine check is to ensure that lysine makes up about 4 percent of the total amino acids in the crude protein of the daily ration. Because grain mixes usually make up only a portion of the total ration, grain mixes for growing horses will be formulated to contain higher amounts of lysine as a portion of crude protein.

Minerals

Minerals, like other nutrients, are needed to replace naturally occurring losses for maintenance and additional levels for production and growth (Table 4). The two most needed, most often balanced for minerals are calcium and phosphorus. Rations are balanced for actual needs of these minerals as well as the ratio of each to the other. For example, an 1,100-pound horse may need about 20 grams of calcium and 14 grams of phosphorus per day to replace naturally occurring losses at maintenance. Needs increase for pregnancy for the development of the unborn foal and lactation because of the large amounts secreted through milk.

The growing horse needs more minerals as compared to mature horses because of the need for bone development. As such, mineral concentrations for growing horses and lactating mares in particular are larger than rations for

Table 4. Comparisons of Daily Mineral Requirements for a Horse with Mature weight of 1,100 pounds[a,b]

State of Production Or Growth	*Copper grams*	*Zinc grams*	*Magnesium grams*	*Potassium grams*
Maintenance	0.1	0.4	7.5	25
12 months of age	0.08	0.32	5.4	17
Early pregnancy	0.1	0.4	7.5	25
Lactation (3 months)	0.13	0.5	11	46
Moderate Exercise	0.12	0.5	12	32

[a] Nutrient requirements are estimated from the National Research Council's Recommendations for Nutrient Requirements of Horses 2007.
[b] These levels take into account all sources of minerals in the diet including hay, grains and supplements.

Table 5. Comparisons of Daily Vitamin Requirements for a Horse with Mature weight of 1,100 pounds[a,b,c]

State of Production Or Growth	*A IU*	*D IU*	*E IU*
Maintenance	15,000	3,300	500
12 months of age	14,500	5,600	642
Early pregnancy	30,000	3,300	800
Lactation (3 months)	30,000	3,300	1000
Moderate Exercise	22,500	3,300	900

[a] Nutrient requirements are estimated from the National Research Council's Recommendations for Nutrient Requirements of Horses 2007.
[b] These levels take into account all sources of vitamins in the diet including hay, grains and supplements.
[c] Different sources of vitamins will have differing concentrations of vitamins so accounting for ingredients and reading labels is important.

maintenance. For example, a mature, nonproducing horse consuming 25 pounds of feed per day could meet its calcium and phosphorus needs by a ration containing 0.2 percent calcium and 0.12 percent phosphorus. Even feedstuffs low in minerals, i.e. native grasses, will contain these levels, so deficiencies are not a large concern. However, needs for lactation will triple the estimated requirements, so rations will need to be more concentrated in these minerals even when considering intakes will be higher. Also, needs for growth are double what is needed when mature. So, rations for growing horses have to be more concentrated in minerals considering the lower daily intake with these larger needs.

Regardless of production status, calcium needs are larger than phosphorus needs. The typical ranges of ratios that keep these needs in check are between 1.5 to 2.0 times more calcium than phosphorus in the total diet. Too much phosphorus may keep calcium from being absorbed, even when adequate calcium is supplied in the diet.

Other minerals of concern include sodium and chloride, which can be supplied free choice. Zinc and copper levels are checked because many forage varieties are low in these minerals. Checking the level of zinc and copper is especially important in growing horse diets. Also, there are a large number of minerals needed in very small amounts, electrolytes, which receive attention in exercising horses because of increased losses in sweat.

Vitamins

Vitamins are grouped into two classes, water or fat soluble. The water soluble vitamins are largely the B vitamins: biotin, thiamin, Vitamin B_{12}, and others not as frequently marketed. Supplementation usually isn't necessary because fresh feedstuffs contain large amounts of these vitamins and the microbes in the horse's digestive tract also provide a substantial source of these vitamins. However, grain mixes will contain supplements of these vitamins because of the variability of need and supply as well as the comparably low cost.

The fat soluble vitamins, Vitamins A, D, E and K, are also supplemented to ensure adequate levels. The need for Vitamin A is larger than the others. Requirements lead to supplements to contain ratios of A, D and E in the ranges of five times more A than D, and about four times more D than E. Horses in production will require more vitamins per day, so supplements are more warranted for exercising, pregnant or lactating horses. Vitamin needs for growth increase the need for D more so than A or E, so supplements will need closer to a 2:1 ratio of vitamin A to D as compared to 5:1 ratio more typically recommended for mature horse diets.

Feedstuff Selection and Feeding Practices

Feeding practices direct the types of feedstuffs which can be fed safely. Alternatively, the types of feedstuffs direct feeding practices. Given the availability, horses will generally eat between 2.5 percent to 3.5 percent of their body weight per day in harvested feed (i.e. 25 to 35 pounds per 1,000 pounds of body weight). To encourage water intake, enhance motility of the digestive tract and help the horse's natural desire to eat more or less continuously, most rations are designed to meet needs of horses at around 80 percent of maximal intake limits (i.e. 20 to 30 pounds per 1,000 pounds of body weight). These amounts are designed for significant levels of fibrous feedstuffs and for sufficient highly digestible energy sources, i.e. fat, starches and sugars, to be fed to meet nutrient demands not supplied in forages.

The horse's digestive tract is very efficient in absorbing nutrients when feeding practices fit the feedstuff; but can be very inefficient when the two factors are not considered in relation to each other. The first portions of the digestive tract that feed travels, the stomach and small intestine, will absorb energy containing compounds, amino acids from protein and minerals and vitamins needed for sound production and maintenance. This occurs from action of enzymes and other chemicals secreted by the horse's digestive tract, and substances that transport compounds into the horse's body. This process is very efficient as long as amounts of feedstuffs do not overwhelm this ability and the feed contains compounds that can be acted upon by enzymes.

The remaining parts of the digestive tract, the large intestine and cecum, house large numbers of bacteria and protozoa, which digest much of what was previously not absorbed into the horse's body. This hindgut digestion by microbes allows for additional nutrients to be absorbed before nutrients are lost as manure. Some compounds are not digestible in the small intestine but are digestible by these microbes. Other compounds which were digestible may have been supplied in amounts that overwhelmed the capability of the small intestine. These compounds also will be digestible by hindgut microbes.

Carbohydrates

Carbohydrates are the most abundant compounds in plants. Carbohydrates supply energy. There are two broad types of carbohydrates: fibrous and nonfibrous. These two types are digested differently and in different locations in the digestive tract. Grains generally contain high concentrations of nonfibrous carbohydrates. Nonfibrous carbohydrates comparably are highly digestible, so have the advantage of supplying a readily, usable source of energy. However, too much nonfibrous carbohydrate intake at one time leads to digestive upset.

Nonfibrous carbohydrates, starches and sugars, which are found in greatest amounts in grains, are nearly 100 percent digestible. Ideally, most of the nonfibrous carbohydrates should be digested and absorbed in the small intestine. What is not digested in the small intestine will be broken down by the microbes in the large intestine and cecum. This microbial digestion supplies additional sources of energy to horses that would otherwise be lost in manure. However, too much of these compounds presented to microbes in the hindgut cause adverse changes in the digestive tract, which lead to colic and founder. Daily allotments must be regulated so amounts presented to the microbes are at a low level. As such, in addition to meeting our scheduling needs, meals are designed to help digestion and increase safety.

Feedstuffs containing large amounts of nonfibrous carbohydrates (e.g. grains) are generally rationed so that no more than 5 or 6 pounds per 1,000 pounds of body weight are fed at one time. Rations containing high levels of nonfibrous carbohydrates are split into two or three a day feedings, so to keep at least 8 hours between feedings. Some grains, e.g. corn, have so much nonfibrous carbohydrates that strict regulation is imperative. Other grains (e.g. low quality oats) may have less starch and sugar as part of total weight, so small changes in amounts per meal are not as critical. Grain mixes may include significant amounts of highly fibrous feedstuffs as part of the mix, so the amounts that can be safely fed in one feeding may be more than the guideline stated above.

Whole plants will contain larger amounts of fibrous carbohydrates. Fibrous carbohydrates range in digestibility from levels near those characteristic of nonfibrous carbohydrates to sources that are completely indigestible. Fibrous carbohydrates are digested almost exclusively in the hindgut by microbes. Digestibility of fibrous carbohydrates will vary greatly because of differences in the structure of the many forms of fiber. Some plants are very digestible, ranging around 80 percent, while others may be less than 30 percent digestible because of the different levels of fibrous compounds. Immature, small grain pastures (e.g. oat, rye or wheat) are examples of a highly digestible fibrous feedstuff that may be so nutritious that intake must be regulated similarly as grain intakes. The less digestible the feed, the more would have to be consumed to meet needs. Because of low digestibility, mature, native pastures or hay with plant varieties with low leaf to stem ratios may not meet energy needs for maintenance even when fed free choice.

Highly fibrous feedstuffs are whole plants or are feed byproducts that have been milled to remove the nonfibrous carbohydrate portions. Because of limited digestibility, many of the high fiber feedstuffs can be fed free choice with little concern for overfeeding. Thus, rations using highly fibrous feeds (hay and pasture) reduce the need to meal feed and regulate intake. Feeding highly fibrous feedstuffs has limitations when costs rise too high for the nutritional value of the feedstuff and when needs for nutrients require a ration with more concentrated ingredients.

Most rations are forage based so to allow for longer, more continual intake and to avoid providing too much nonfibrous carbohydrates. As such, hay or pasture make up significant portions of the total ration for most horses. Grains are added to balance and supplement what is not supplied in the forage. Significant amounts of grains are needed with some production states in order for needs to be met below intake limits. Rations for horses will range from 100 percent forage to near 50:50 ratios of forage to grain by weight. If forages are unavailable or not desired, then grain mixes will contain significant levels of high fiber feeds. These mixes, which are intended to be the sole source of feed, are classified as 'complete feeds.'

Protein Quality

High quality protein sources are fed to meet demands for amino acids. Enzymes in the small intestine will break down protein into amino acids and these amino acids will be transported into the horse's body intact. Protein in high protein feedstuffs such as soybean meal may be 70 percent digestible in the small intestine as compared to hay digestibility of 40 percent within the small intestine.

Protein not absorbed from the small intestine becomes feed for the microbes in the hind gut. These microbes destroy the amino acids, so what is produced in the hindgut is not a supply of essential amino acids. Rather, protein is broken down into carbon and nitrogen. Any nitrogen that is absorbed is used to build amino acids that a horse's body can make, or other compounds needing nitrogen as part of its makeup. Because the need for essential amino acids are higher for growing horses as compared to mature, nonproducing horses, rations for growing horse are higher in percent protein and higher in essential amino acids. Splitting daily intakes into several meals per day can guard against overwhelming small intestinal digestion, so young horses are typically meal fed at least twice daily when fed high quality protein feeds. There is some research that suggests feeding weanlings and yearlings three times daily maximizes amino acid intake in the small intestine.

Utilization of Mineral and Vitamins

Less is known about the value of feeding different mineral and vitamin sources. Some mineral sources are likely to be more digestible than others, especially sources which are chelated (combined chemically) with organic compounds. However, equine research on digestibility of different sources of minerals is very limited and results between studies appear contradictory. As intake levels of minerals affect the apparent digestibility, influencing factors such as amounts fed and variability of other types of compounds in the diet likely affect results. Even less is known about the absorption of vitamins.

Safety

Feed is intended to supply nutrients to horses, not make them sick. However, colic leads the list of most serious and recurring problems identified with the feeding of horses. Colic, meaning pain in the abdominal cavity (gut), can and

will likely happen to some extent to all horses. Nutritionally induced colic is but one cause of abdominal pain, but one that is too often alluded to when incidences occur.

Horses can efficiently and safely digest a variety of feedstuffs: growing plants, harvested forages, grains and grain products. No feeds are 100 percent safe, 100 percent of the time; even the most commonly fed feedstuffs may trigger a colic episode. Feed selection and feeding routines have to be directed toward safety to keep severity and frequency of colic to a minimum. Some of the more important characteristics of feeds and feeding patterns as related to feed safety follow.

Clean

Clean refers to being free of contaminants that might be harmful. The list is large, maybe endless, when thinking about the possibilities of contaminants: feed through drug products not intended for horse rations, toxic levels of minerals inadvertently being included, naturally occurring toxins in certain feeds, insects, sand, indigestible materials and so forth.

The term clean is also used to describe feed that is fresh and has little to no small particle size in the mix. Particle size is not necessarily the problem in itself, as ground mixes have been fed successfully to horses in a variety of management routines. Rather, feed with a high level of dust and small particle size may have feedstuffs that aren't intended to be in the mix (i.e. grain screenings), may suggest poor milling practices or may be more prone to contain mold when stored for long periods of time or in humid environments.

Consistent

Consistent refers to uniformity of the ingredients of the feed mix and the physical size and appearance of individual particles within successive batches of a feed. Lack of consistency is more of a concern with mixes containing processed feeds, e.g. pelleted mixes. Pelleted feed is successfully fed to hundreds of thousands of horses daily, so one can't simply point at the manufacturing process as unsafe. However, one of the discussed concerns with pelleted feed is that different batches may appear the same but contain different feedstuffs. Also, certain feedstuffs that work well with the pelleting process increase the variability of nutrients more than desired because of the increased variability of carbohydrate compounds in the feedstuffs.

The largest concern with individual feedstuff variability is with the different levels of carbohydrates that grains and grain byproducts might contain. To safeguard against this variability, mixes should restrict the allowable level of feedstuffs that are high in nonfibrous carbohydrates or are feedstuffs that are likely to be highly variable in amounts of these carbohydrates from source to source. Also, consistency in particle size and density (hardness of pellet) will influence consumption rates and digestion of feedstuffs. As such, purchasers of feeds want assurance of consistency of nutrient concentrations of feedstuffs and uniformity of the physical characteristics of grain mixes.

Regulating Feedstuff Variety, Amount and Timing of Feeding

Feeding managers regulate amounts and timing of feedstuffs in efforts to increase safety. Given free access to abundant feed, horses will self limit their intake mainly to their mechanical capacity to keep their digestive tract full. Unless over conditioning (too fat) is a concern, some feedstuffs can be offered free choice in unregulated amounts and timing, and in reality, may be best fed that way. Others fed free choice almost guarantees episodes of severe colic. Of all the commonly fed compounds, overeating of nonfibrous carbohydrates is the largest safety concern. Intake of nonfibrous carbohydrates, the starches and sugars, needs to be carefully regulated. Consuming unregulated amounts of feedstuffs high in the nonfibrous carbohydrates (e.g. grains) easily overwhelm the capacity of safe digestion in the horse. These feedstuffs are rationed by meal feeding routines.

Diets of horses come in a variety of forms and contain a vast array of feedstuffs. In an effort to promote consistency, some owners feed a single grain and a forage source (e.g. the traditional feeding of oats and alfalfa hay). Others feed grain mixes containing a variety of feedstuffs and alter forage with available options of hay and pasture from season to season. Grain mixes are balanced to meet the requirements of the horse, assist digestion and can increase the variety of feedstuffs that can be fed. However, mixing can produce feeds similar in size and appearance that are very different in nutrient content. For example, a pelleted corn, wheat midds and alfalfa meal combination might be formed into a pellet that appears similar to a pellet containing only alfalfa meal. Not knowing differences in nutrients that the pellets contain can easily lead to over or under feeding. Also, the simple difference in density of rations, the weight per volume, can lead to unsafe feeding when rationing diets on a volume basis.

Timing of meals will be influenced by management and use needs. Small amounts of grain (i.e. 5 pounds or less for a 1,000-pound horse) may be fed in a single feeding per day with expectations that forage will be available the majority of the 24-hour period. Diets higher in amounts of grain or high quality forage are usually rationed into two feedings per day, with the total daily allotments of grain and forage fed at the same time rather than splitting the feedings by feedstuff type, (i.e. all the grain in the morning and forage in the evening). For the overwhelming majority of management situations, there appears to be little to no benefit for digestion to provide grain and/or forage prior to the other during a single meal (i.e. waiting 30 minutes following grain before allotting forage). In general, two a day feedings are best utilized when maintaining a minimal time period of 8 hours between feedings. Those management situations where young, rapidly growing horses are fed high quality protein in efforts to maximize rate of gain may increase absorption of essential amino acids when grain is split into three feedings per day.

Related OSU Fact Sheets on Horse Nutrition and Feeding Management:

ANSI-3973 Feeding Management of the Equine
ANSI-3997 Nutrient Needs of Horses
ANSI-3928 Evaluating Rations for Horses
ANSI-3923 Use of By-Product and Nontraditional Feeds for Horses

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