same horse on different days. Water consumption should be monitored whenever possible so normal intake levels can be assured and observed. Sources that supply fresh, clean water supply are preferred as contaminants may decrease voluntary intake or contain products harmful to the health of the horse.

Estimates for Nutrient Requirements

The National Research Council of the National Academies provides documents on nutrient requirements of animals. The estimates provided in the tables in this Fact Sheet are based on recommendations from the National Research Council. Tables 1 through 5 display how nutrient requirements are expected to change with differences in body size or production. The tables display estimates for requirements of digestible energy, crude protein, and several minerals and vitamins.

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 (pounds)*	*Calcium (grams)*	*Phosphorus (grams)*
Maintenance (1000 lb)	15	1.2	18	13
Maintenance (1100 lb)	16.5	1.4	20	14
Maintenance (1200 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 (body weights of 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 (1000 Calories), a unit of energy potential.

Table 3. Comparisons of Daily Energy, Protein and Mineral Requirements for Growth (Mature weight of 1100 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 (1000 Calories), a unit of energy potential.

Table 4. Comparisons of Daily Mineral Requirements for a Horse with Mature weight of 1100 pounds.[a,b,c]

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.
[b]Different sources of minerals will have differing concentrations of minerals so accounting for ingredients and reading labels is important.

Table 5. Comparisons of Daily Vitamin Requirements for a Horse with Mature weight of 1100 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.
[b]Different sources of vitamins will have differing concentrations of vitamins so accounting for ingredients and reading labels is important.

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Nutrient Needs of Horses

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http://www.osuextra.com

Introduction

Horses are fed a variety of forms and types 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, what traditionally has been 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 nutrients 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 the nutrient needs of horses and how these needs change with age and production status. Extension Fact Sheet ANSC-3928 "Evaluating Rations for Horses" provides additional information for assessing how well nutrient needs are met with alternatives of available feeds.

Nutrient Needs

The basic classes of nutrients are energy, protein, minerals, vitamins, and water.

Energy

Energy is not a nutrient in the sense of an identifiable substance; rather it is utilized as fuel for body processes, and is released when energy-containing substances are broken down by the horse's body. A calorie is a unit of energy that represents a standard amount of heat released when an organic compound is broken down. Calorie with a capital C is the unit used in human food literature. A Calorie is a kilocalorie which is 1000 calories. Energy requirements for horses are expressed as digestible energy needs per day in Megacalories, which is one million calories, or 1000 Calories (kilocalories).

Digestible energy is the portion of the energy fed, gross energy, that is absorbed from the digestive tract (Diagram 1). In order to accurately determine the digestible energy value of a ration, gross energy and energy remaining in the manure would have to be determined experimentally. Feed laboratories and nutrition tables use estimates for digestible energy based on the levels and types of energy-containing substances in a particular feedstuff.

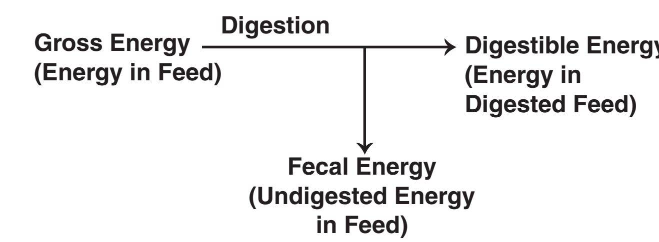

Diagram 1. Relationship of Gross and Digestible Energy in Feeds.

The energy-containing substances in feeds are carbohydrates, fats, and protein. Carbohydrates are the largest suppliers of energy. There are two general types of carbohydrates based on chemical structure, which in turn, affects how the types are digested by the horse.

The two types of carbohydrates are fibrous and nonfibrous carbohydrates. Each type contains a variety of compounds that vary in digestibility. Fibrous carbohydrates provide structure to plants. Large amounts are found in seed coats of grains and stems of plants. Horses do not secrete enzymes that break down fibrous carbohydrates; rather fibrous carbohydrates are digested by bacteria and protozoa in the horse's digestive tract. Portions of the products of this microbial digestion are absorbed by the horse and used for energy. These microbes are located mainly in the cecum and large intestine, which are components of the digestive tract located after the stomach and small intestine (Figure 1.).

Hemicellulose and cellulose are the main types of fibrous carbohydrates in horse diets. Fiber digestibility will decrease as the amount of cellulose increases as compared with hemicellulose and some of the other smaller fibrous compounds. The presence of lignin, an indigestible compound found in large amounts in woody plants, is especially important. Lignin is not digested by the horse's enzymes or microbes in the digestive tract. Further, complexes with cellulose are formed that decreases the digestibility of cellulose as the amount of lignin increases. The relative amount of cellulose and lignin increases when plants mature, so mature plants are not as digestible as when immature.

The relative amounts of fibrous carbohydrates also vary between plant types and parts of the plant. Plants with large stems and few leaves will be less digestible because of larger amounts of indigestible fiber. Pasture plants and hay generally have more fibrous carbohydrates than levels found in the harvested grains. Grains will have large amounts of nonfibrous

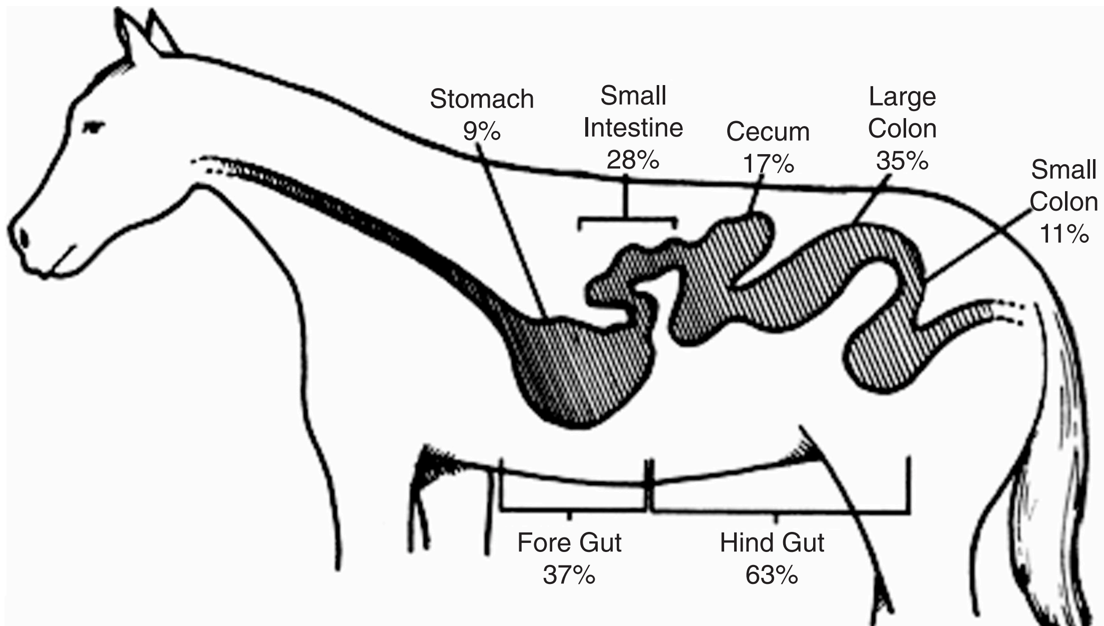

Figure 1. Relative capacities of parts of the equine digestive tract.

carbohydrates as compared to levels found in most grazed or harvested forages.

The nonfibrous carbohydrates are mainly starches and sugars. Analyses for nonfibrous and nonstructural carbohydrates account for much of the same types of carbohydrates. Plants have larger levels of nonstructural carbohydrates when immature and growing. Seeds of plants (grains) have relatively large amounts of nonstructural carbohydrates as compared with stems and leaves. Different plants and grains vary in the levels of these carbohydrates. For example, corn and wheat typically will have more starches and sugars compared to oats.

Nonfibrous carbohydrates are more digestible than fibrous carbohydrates, as nonfibrous carbohydrates are partially broken down by enzymes secreted by the horse and absorbed in the small intestine. Nonfibrous carbohydrates not absorbed in the small intestine are digested by microbes in the cecum and large intestine, and portions of the products of this microbial digestion are absorbed for energy use.

More nonfibrous carbohydrates will pass to the cecum and large intestine as larger amounts are fed in a single meal. Microbes in the cecum and large intestine readily digest nonfibrous carbohydrates. Too much microbial digestion of these compounds occurring too quickly causes a build up of substances that alter the normal state of the horse's digestive tract. These changes can lead to laminitis and colic.

Because of this, the amounts of nonfibrous carbohydrates fed as a meal should be regulated. Horses introduced to pastures with large quantities of immature, growing forage should be limit grazed. Grains should be limited at or below levels of about 0.5% of body weight per meal, i.e. 6 pounds of a grain mix or less per meal for a 1200 pound horse. Grain mixes should be split into several meals per day when larger amounts of nonfibrous carbohydrates are fed (See Extension Fact Sheet ANSC-3973 "Feeding Management of the Equine").

Fats are a group of chemical compounds (fats, oils and waxes) that contain fatty acids. Some of the fatty acids are essential, meaning they are needed but not produced by the body itself. The breakdown of fat produces about twice the energy as compared to similar amounts of carbohydrates or protein. Feeds have smaller amounts of fat than carbohydrates or protein. Some of the grain byproducts used for feed will have larger percentages of fat because carbohydrates are removed during the milling of the grain. Fat amounts of feeds are increased by using certain byproducts or by adding vegetable oil to mixes (See Extension Fact Sheet ANSC-3923 "Use of By-Product and Nontraditional Feeds for Horses").

The body also breaks down dietary protein for energy use. However, energy production is more efficient when there are enough carbohydrate and fat compounds to produce the majority of energy needs. Dietary protein is supplied for the main purpose of supplying amino acids rather than as a source for energy.

Mature horses of larger weight require more energy to maintain their body than do smaller horses. Working horses will need more energy than horses not receiving forced exercise. Mares producing foals, lactating mares and growing horses will need large amounts of energy to fuel their production of body tissue. Similarly, energy needs are larger when energy use is increased to stay warm during cold environmental temperature (normally below 30° to 40° F if horses are adapted to the cold).

Energy intake above the amount needed to fuel the body for maintenance, production and growth processes will be deposited as fat (See Extension Fact Sheet ANSC-3920 "Body Condition of Horses"). Horses in good body condition receiving insufficient daily energy intake will burn energy that is stored as fat. Horses in poor body condition receiving insufficient daily energy intake will decrease in body weight and body condition, and over time will develop serious health problems that may lead to death (See Extension Fact Sheet ANSC-3927 "Refeeding the Poorly Conditioned Horse").

Protein

Protein is made of amino acids, and horses actually have an amino acid requirement rather than a requirement for protein. Amino acids are needed to maintain and produce muscle, enzymes and hormones, and play key roles in many different body processes. Part of the protein in feed is digested by enzymes in the small intestine and absorbed as smaller units containing the dietary amino acids. Otherwise, the

protein is broken down by microbes in the cecum and large intestine beyond the amino acid level, or leaves the body undigested.

Some of the amino acids must be supplied in the diet because the horse's body cannot make them. These are collectively termed as essential amino acids. Lysine is the most limiting amino acid for growth as it is an essential amino acid and is needed in relatively large amounts. Feeds containing relatively large amounts of essential amino acids are considered to be higher quality protein sources because essential amino acid levels align more closely with needs. Feeds vary in the amount of protein and the relative distribution of amino acids of the protein, i.e. soybean meal contains more lysine than cottonseed meal. To ensure a good balance of amino acids, the minimum level of lysine should be at or above 4 percent of the total crude protein intake, especially for growing horse diets.

Protein needs are expressed as crude protein which is the amount in the ration. Like all nutrients, protein must be digested to be usable. Generally, protein in grain and grain by-products is more digestible than protein in forages. Horses need a certain amount of protein per day for maintenance of their body. As with energy, states of production and growth will increase protein requirements.

Increased protein needs can be met by feeding more of a diet without changing the percent protein concentration of the diet. Other situations will require diets with greater protein density (crude protein, %) to meet the larger demands. Generally, diets of growing and lactating horses will be formulated to contain a higher crude protein percentage as compared to diets formulated for other horses. Although losses of protein increase with increased sweat loss during exercise, protein density of diets for mature, exercising horses does not necessarily require increasing the protein densities above that in maintenance diets. Increased requirements for protein during exercise can be met when amounts of the maintenance ration are increased to meet the added energy to meet requirements. Similarly, the increase in protein needs for pregnancy may be met when more of the maintenance diet is fed to meet weight gain needs in late gestation.

Minerals

Minerals are inorganic compounds needed as components of body tissue, and as facilitators of various body processes. The two minerals of largest requirements are calcium and phosphorus, especially when tissues that contain large amounts are actively growing. Thus, relatively large amounts of calcium and phosphorus are required in the diet of growing horses that are building bone. The total dietary supply of minerals should contain more calcium than phosphorus as needs for calcium are greater than phosphorus, and large amounts of phosphorus can interfere with calcium absorption. Diets are recommended to contain about 1.5 to 2.5 times more calcium than phosphorus.

Other minerals with established requirements include sodium, potassium, zinc and copper. Salt, sodium chloride, is a normal addition to grain mixes at about the 0.5 percent level and supplied free choice in the form of blocks. Some sources of salt contain trace minerals, which are several different minerals needed in trace amounts. The need for copper and zinc is much less than needs for calcium or phosphorus; however, these are two additional minerals routinely balanced for in rations, especially for diets formulated for growing horses.

Many of the minerals needed in small amounts do not have well established requirement levels. Many of the minerals have a wide range of dietary concentration acceptability, as increases in intake above what is actually needed are easily expelled from the body. Others may be toxic at high levels, so care must be taken to account for all sources of minerals before large amounts of mineral supplements are fed. Commercially prepared feed mixes may include added minerals, so additional sources are not needed. On-farm topdressing of mineral supplements should account for levels in feed. Using a single source of mineral supplement instead of multiple sources will guard against oversupply. With the exception of salt, voluntary mineral intake is not highly correlated with the actual mineral needs of horses. As such, minerals are best provided as part of a formulated mix. The ability of free choice mineral supplements to provide minerals in amounts needed depends on the formulation of the mineral supplements and the intake patterns of horses.

Vitamins

Vitamins are organic compounds needed in trace amounts that regulate a multitude of bodily functions. There are two general classes of vitamins: fat soluble and water soluble. Fat soluble vitamins are absorbed with fat, water soluble absorbed with water. The main fat soluble vitamins are vitamins A, D, E, and K. The water soluble vitamins are the B vitamins and vitamin C.

Most, if not all the vitamin needs of horses are supplied by levels naturally occurring in grains and forages. Green forages are good sources of vitamins A and E. While most if not all of the horse's maintenance requirement for vitamin A is met by a compound present in forages, vitamin A needs increase in production and growth such that supplementation may be necessary. Needs for vitamin A are the largest, followed by Vitamins D and E. Given access to sunshine and exercise, most horses will not need Vitamin D supplementation unless they are rapidly growing or preparing for heavy exercise at young ages. The B vitamins are thought to be produced in sufficient amounts to supply the needs of most horses, although it is recommended frequently to supplement rations used for horses being heavily worked.

Commercially prepared horse feeds routinely supplement fat soluble and water soluble vitamins at levels above suggested requirements, so the need for on-site supplementation is not necessary. Excess intake of fat-soluble vitamins A and D is detrimental since fats, and the substances soluble in them, are poorly excreted from the body. Excessive intake of water-soluble vitamins is rarely detrimental as water-soluble substances are readily excreted from the body. It is cautioned to feed vitamin premixes only at levels recommended on the label and to account for sources added to grain mixes before deciding to topdress.

Water

Water is not often thought of as a nutrient, although lack of water intake causes illness and death much more quickly than feed nutrients. Water requirements vary with losses, so horses housed in hot environments or those losing large amounts through sweat, respiration, or milk will need more water than nonproducing or sedentary horses. Intake is expected to be larger in hot environments, with larger feed intake or larger horses.

With the possible exception of the extremely hot horse immediately following hard exercise, water should be offered free choice as the bigger concern is lack of intake. Extra intake of water is easily expelled via urine. Voluntary water intake is expected to vary considerably between horses and by the