NUTRITION OF THE PERFORMANCE HORSE

Kentucky Equine Research®

3910 Delaney Ferry Road
Versailles, Kentucky 40383
859-873-1988 | fax 859-873-3781
info@ker.com

7/35 Dunlop Road
Mulgrave 3170, Victoria, Australia
03 8562 7000 | fax 03 8562 7007
advice@ker.com

ker.com | Equinews.com

TABLE OF CONTENTS

INTRODUCTION

Horses evolved as herbivores with voluminous hindguts designed to continuously process large amounts of grass. Through much of their evolution, horses were not asked to work or perform, and forage-only diets were sufficient for survival.

With domestication, however, the energy requirements of most horses could not be met with diets made up solely of forages. The solution to this energy deficit was cereal grains. These grains are rich in starch, which is a versatile energy source. Too much starch, though, can cause problems. The archetypal diet of forage, unfortified cereal grains, and water—"hay, oats, and water"—remained in place for nearly 2,000 years.

In fact, nothing much changed until the mid-1900s, when scientists began pinpointing vitamin and mineral requirements of horses. Beginning in the 1960s and extending through the 1990s, researchers revolutionized knowledge of nutrition by using information available from other species and refining it for use in horses.

By the 1980s, researchers investigated alternative sources of energy, aside from starch-laden cereal grains, that could fuel even intense athletic pursuits. Studies on fat and fermentable fiber ushered in a new era of performance-horse feeding.

More recently, equine nutritionists and veterinarians have worked together to find nutritional solutions to problems that affect performance horses, namely different muscle ailments and electrolyte replenishment after exertion.

Nutritional Management of the Performance Horse provides a broad overview of how best to nutritionally manage equine athletes. It includes practical strategies for common problems and, when appropriate, gives feed and supplement recommendations.

DETERMINING WORK INTENSITY

Optimal nutrition of performance horses hinges foremost on the intensity and duration of exercise they perform. Just as the diet of a human bodybuilder is dissimilar to that of a marathon runner, horses are fed with performance goals in mind. Accurately assessing the level of work performed by an individual horse is essential in determining the amount and type of feed needed.

In the body, most of the energy is produced by aerobic or anaerobic metabolism. The breakdown of carbohydrates, fats, and protein into energy with the involvement of oxygen is termed an aerobic reaction. Because oxygen is required, this energy-producing process is slower but can be sustained for longer duration. The process of converting glucose or glycogen to energy that does not require oxygen is an anaerobic reaction. This produces energy rapidly. The end product is lactic acid, which causes fatigue if too much accumulates in the body. Equine nutritionists divide work into three classes based on how horses derive energy from their bodies to fuel exercise.

High-intensity, short-duration work includes performance events with a primary sprint component. Quick acceleration and top

speed over a short distance require mainly anaerobic energy production. Examples of high-intensity, short-duration work are Thoroughbred, Standardbred, and Quarter Horse racing; barrel racing and pole bending; rodeo events such as heading, heeling, calf roping, and steer wrestling; and draft horse pulling contests.

- Traditional carbohydrate-laden feeds, which include most low-fat textured or pelleted concentrates, and forage may satisfy the nutritional requirements of horses performing this type of exercise. The digestion of carbohydrates provides muscles with glycogen, a fuel critical for high-intensity performance. As workload increases and energy reserves empty, large quantities of complex carbohydrates may be necessary to maintain body condition.

- Horses fed high-fat feeds typically require fewer pounds to satisfy caloric requirements because fat delivers 2.25 times the energy of an equal amount of carbohydrate.

Moderate-intensity, medium-duration work includes exercise that taxes, but not necessarily exhausts, a horse and requires both aerobic and anaerobic energy production. Intensive show training and competition is the primary moderate-intensity, medium-duration work. Horses are asked to perform for several minutes, perhaps close to an hour, and often more than once per day.

- Feeds formulated for horses performing moderate-intensity, medium-duration work should be similar to those fed horses involved in high-intensity, short-duration performance. One primary difference, however, involves feeding management. Horses in this classification may require less feed to support the work effort.

Low-intensity, long-duration work includes endurance activities that typically last two or more hours. Aerobic energy production is required to sustain this type of exercise. Examples of low-intensity, long-duration exercise include endurance races, competitive trail rides, and draft horse, ranch horse, and heavily used school horse work.

- As workouts become longer and lower in intensity, high-quality forage, that which is low in indigestible lignin, becomes more

imperative in the diet. Not only is fiber a source of energy, but it holds water and electrolytes in the hindgut. Horses can draw on these reserves during exercise, effectively suppressing dehydration. In particular, beet pulp and soybean hulls are considered "super fibers" because of their high bacterial fermentation rate and water-holding capacity.

Not all equine athletic endeavors fit neatly into one of the aforementioned classifications. Some activities mesh properties of more than one. With its long, circuitous courses and explosive jumping efforts, show jumping, for instance, represents both high- and moderate-intensity activity. Polo, a fast-paced sport of sudden accelerations and abrupt stops mixed with easy canters and full-tilt gallops, combines all three exercise classes.

Simpler explanations of workloads, ones that may be more appropriate for horse owners and feed manufacturers, appear below. These designations are often listed as part of the feeding instructions on feed bags or tags.

Horses in **light work** are exercised three or four times weekly in preparation for trail riding, pleasure driving, or as light training for low-key show events such as western pleasure, trail, and lower-level dressage.

Horses in **moderate work** participate in a near-daily, structured training program. Reining horses, jumpers, upper-level dressage horses, polo ponies, endurance horses, and young racehorses undergoing breaking and training would fall into this category. Horses involved in rodeo events are also included in this category.

Horses in **heavy work** train and compete at the peak of their physical abilities. Racehorses on an active racing schedule and three-day event horses preparing for upper-level competition fit into this classification. Few horses that participate in typical pleasure rides, horse shows, or rodeos fit in this grouping.

Deciding the intensity of a horse's exercise program is not difficult, but owners are often left to determine this on their own with few or no guidelines. Using the aforementioned classifications, caretakers and consultants can ascertain the workload of a horse accurately and feed it accordingly.

FORAGE FOR PERFORMANCE HORSES: TYPES AND SELECTION

Work intensity often dictates the quality and quantity of forage required by performance horses. A cold-blooded carriage horse that is hitched a few times a month for leisurely strolls would need much different forage than a high-goal polo pony exercised intensely most days of the week. Regardless of the horse's use, forage should always be a prime consideration in formulating a diet.

Why should owners of performance horses be concerned about forage? Due to its unique and delicate gastrointestinal system—a tract that depends on near-constant forage consumption to function optimally—a horse needs to consume a *minimum* of 1% of its body weight daily as forage in the form of pasture, hay, cubes, pellets, or chaff.

Most performance horses are fed more than this, consuming up to 2% of their body weight per day. This means that a 1,000-lb (450-kg) performance horse will easily consume 11-15 lb (5-7 kg) of forage daily, and will likely also be offered a concentrated form of calories in the form of textured or pelleted feed on top of that to fuel energy demands.

Pasture provides the quintessential forage for horses, especially if it has been cultivated to offer horses varying types of plants and is cared for through regular fertilization, reseeding, weed control, and rotation. Depending on pasture quality and the amount of time allotted to grazing, performance horses may be able to fulfil their entire forage requirements from pasture alone. Performance horses allowed time on pasture not only derive the obvious nutritional benefits, but pasture provides other advantages, including the freedom to roam. Moving about is valuable for the musculoskeletal mechanisms of horses, especially older athletes whose joints may be suffering from the cumulative effects of wear and tear.

Horses that have inappetence due to diet monotony will often show increased interest in their normal concentrates and hay if given time each day to graze. Time on pasture also allows horses a fresh perspective on life, and this often gives them added interest in their work.

TIPS FOR PURCHASING HAY

Most horsemen buy hay based on how it looks, smells, and feels. These are qualitative factors, and they are important. When appraising hay, keep in mind the following 10 points:

- Ask for one or several bales be opened so the inside can be evaluated. Slight discoloration on the outside of bales is not a concern, especially in stacked hay.
- Choose hay that is as fine-stemmed, green, leafy, and soft to the touch as possible.
- Avoid hay that is excessively bleached or discolored, or that smells moldy, musty, dusty, or fermented. Avoid hay that contains significant amounts of weeds, dirt, or other debris.
- Check for leaf loss. If the leaves of alfalfa or clover hay fall too easily off the stems, the horse may not have a chance to eat them.
- Examine the leaves, stems, and flowers or seed pods to determine the level of maturity. Select hay that has been baled when the plants are in early bloom (for legumes) or preferably before seed heads have fully formed in grasses.
- Examine hay for signs of insect infestation or disease. Be especially careful to check for blister beetles and other insects in alfalfa.
- Reject bales that seem excessively heavy for their size or feel warm to the touch. These may contain excess moisture that could cause mold or spontaneous combustion.
- When possible, feed hay within a year of harvest to guarantee the best nutritional value.
- Store hay in a dry, sheltered area, or cover the stack to protect it from the elements. Allow some air circulation when covering with plastic or tarps.
- Feed hay in a way that reduces wastage. Hay feeders or nets are useful.

Several factors affect **hay** quality. These include plant species, stage of maturity at harvest, weather conditions during harvest, storage conditions, and age of hay. Though all of these factors should be considered when assessing the suitability of a particular forage for performance horses, most important of these are species and stage of maturity.

Species. Most forages for horses can be divided into one of three categories, grasses, legumes, or a mixture of both. Grasses contain much structural matter in their leaves and leaf sheaths. This can be as important as, or more important than, the stem in holding the plant upright.

Examples of grass forages used for horses include timothy, orchardgrass, bromegrass, and fescue. Legumes, on the other hand, tend to be stalky. Their leaves have little structural function and form on the ends of woody stems. The primary legumes used as forages for horses are alfalfa and clover.

Stage of maturity. Generally, as plants mature they become less digestible because a greater proportion of their mass becomes structural. Legumes tend to mature by decreasing leafiness and increasing stem-to-leaf ratio. Alfalfa leaves maintain the same level of digestibility throughout their growth. Their stems, however, decrease dramatically in digestibility as they mature because they become highly lignified to support the extra weight of the plant.

The leaves of grasses serve more of a structural function. As they mature, these leaves become more lignified and less digestible. Because the stems of certain grasses serve a reserve function, they may actually be more digestible than the leaves at a later stage of maturity. When forage is grazed as pasture, its nutrient quality is almost always higher than when it is harvested as hay, unless the pasture is the dead aftermath left over from the previous growing season. New spring pasture can be quite low in fiber content and high in soluble carbohydrates.

Popular **alternative forage** sources include hay cubes, hay pellets, and chaff. Hay pellets and cubes made from good-quality forage can help satisfy a horse's nutritional requirements, providing adequate fiber to keep the gastrointestinal tract fully functioning.

Hay intended for cubes and pellets is sun-cured and ground, then mixed with a binder and

DIGESTIBILITY OF FORAGE

All forages are composed of two primary components, cell contents and cell wall. Cell contents contain most of the protein and all of the starch, sugars, lipids, organic acids, and soluble ash found in the plant. These components are degraded by enzymes produced by the horse and are highly digestible. The cell wall encompasses the fibrous portion of the plant, which is resistant to digestive enzymes produced by the horse. The primary components of the cell wall are cellulose, hemicellulose, and lignin.

The nutritive value of forages is determined by two factors: (1) fiber content, or the proportion of the plant that is composed of cell wall, and (2) fiber quality, or the degree of lignification. These factors are important because the horse can digest practically all of the cell contents found in forages, but bacterial fermentation can digest only 50% or less of most plant cell wall. The degree to which plant cell wall is digestible is largely dependent on the amount of lignin it contains.

Forage analysis yields important values that can assist in choosing hays, including acid detergent fiber (ADF) and neutral detergent fiber (NDF).

At a similar stage of maturity, legumes tend to be higher in protein, energy, and calcium than grasses. ADF (a measure of lignin and cellulose combined) does not vary much between grasses and legumes at the same stage of maturity. NDF (the sum of lignin, cellulose, and hemicellulose), however, is much higher in grasses than legumes, as grasses contain a great deal more hemicellulose than legumes.

Therefore, evaluating the fiber content of forages based on ADF alone underestimates the total cell wall content and overestimates the total energy content of a grass. Hemicellulose is typically only 50% digested in the horse, and cell contents are almost completely digested. This means that the digestible fiber content of grasses is much higher than it is in legumes of similar maturity. Because of these factors, legumes contain 20-25% more digestible energy than grasses at the same maturity. In certain instances, the amount of legume hay fed to performance horses may be limited so that the horse doesn't get too fat.

set into its final cube or pellet form. Hay made into pellets goes through more intensive grinding than hay intended for cubes.

Cubes and pellets present certain advantages when compared to more traditional hay. Like other processed feeds, the guaranteed levels of protein, fat, and fiber must be printed on the bag or feed tag, ensuring consistency of the product. In contrast, the quality of baled hay can differ from field to field, or even within the same field. Cubes and pellets are also easier to measure, feed, and store than baled hay, and the minimal dust and ease of soaking makes them ideal for horses with respiratory or dental problems.

On the downside, the purity of cubes and pellets can be difficult to decipher, as it's more difficult to spot foreign matter that may have filtered in during processing. Weeds are easy to see in loose hay, but impossible to identify in cubes and pellets. The best way to avoid quality issues is by buying pellets or cubes from a reputable manufacturer.

Another potential issue is the speed with which horses can consume their allotment of cubes or pellets, potentially leading to boredom-induced behaviors such as wood-chewing. A small amount of long-stemmed forage, perhaps 0.5-1 lb (0.2-0.5 kg) per day, should be offered to keep horses on completely cubed or pelleted forages busy.

Chaff is simply chopped forage, often mixed with molasses to minimize dust or oil to increase the energy value. Traditionally, chaff was a method of feeding poor-quality forage such as straw in a form that was appealing to the horse.

Now, though, chaff is often made from good-quality forage.The length of the chop varies from 1-2 inches (2.5-5 cm), depending where it is made.

Chaff adds bulk to a diet without providing too many calories, and keeps the stabled horse busy eating. Chaff can be mixed into the ration to slow down the feed intake by horses that chronically choke as a result of bolting their food.

SAMPLING TECHNIQUES FOR FORAGE ANALYSIS

Accurate hay analysis depends on sample quality. In short, laboratories cannot do a worthwhile job if they have only poor samples to analyze. Complete flakes of hay, handfuls of hay pulled from a bale or grabbed from the hay feeder, or small wads of hay cut up with scissors are not quality samples and cannot be used by a laboratory.

The only way to obtain a proper hay sample is by using a bale probe or corer. This is typically a metal tube 15-18 inches (38-46 cm) long and sharpened at one end. Depending upon the type of probe, it is either hand-operated or may be coupled to an electric drill. Feed stores and agricultural extension offices may have corers available for loan.

Bales should be probed in the center of the small, square end. The probe takes a representative cross-section as it spins and cuts its way through the bale. The resulting core sample will proportionately reflect the leaf and stem material in the bale. Typically, obtaining and combining core samples from 10 to 20 bales will form a worthy composite sample.

CONCENTRATES

Because of the energy requirements of exercise, most performance horses cannot fuel work and maintain body condition on forage alone. While forage should be an essential component of any diet, a concentrated source of calories is required for optimal health and well-being of most performance horses.

Among the nutritional factors required for optimal health and well-being, energy ranks first and foremost for performance horses. Energy is not a nutrient per se but is, rather, a measure of a feed's potential to fuel physiological processes and athletic endeavors.

Fueling exercise requires the conversion of chemically bound energy in feed to mechanical energy for musculoskeletal movement. Because horses do not eat continuously during exercise, much of the energy from feed must be stored in the body for later release. Horses store energy in different forms, such as intramuscular accumulation of glycogen and triglycerides, and extramuscular stockpiles of adipose tissue and liver glycogen. Many factors determine the proportion of energy derived from each storage form, including type of feed, speed and duration of work, fitness level, muscle fiber composition, and age of the horse.

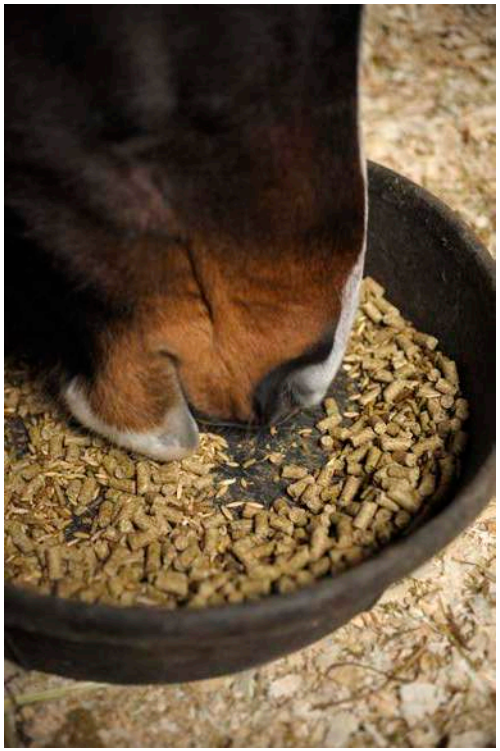
Dietary energy is usually expressed in terms of kilocalories (kcal) or megacalories (Mcal) of digestible energy (DE), or joules (kilo or mega) for the international community, all of which refer to the amount of energy in the diet that is available for absorption by the horse. Digestible energy requirements are calculated based on the

horse's maintenance DE requirement plus the additional energy expended during exercise. Horses derive DE from four dietary sources: starch, fat, fermentable fiber, and protein.

Energy and Substrates

Starch, a carbohydrate composed of several glucose molecules, is the primary component of cereal grains such as oats, barley, and corn, making up 50-70% of the grain's dry matter. Starch has proven to be a versatile energy source for performance horses. During digestion, starch is broken down to glucose in the small intestine, where it is absorbed into the blood. Once in circulation, glucose can be used for different purposes, though primarily it is oxidized directly to produce adenosine triphosphate (ATP), the molecule used to fuel muscular activity, or it is used to generate stored energy in muscle glycogen, liver glycogen, or adipose tissue.

Starch is the dietary energy source of choice for glycogen synthesis, because starch digestion results in a direct rise in blood glucose and insulin, two of the mostimportant factors involved in glycogen synthesis. A performance horse's diet can only contain so much starch, however. If large amounts of starch are fed in a single meal, the small intestine becomes overwhelmed and unable to digest and absorb all of it. Undigested starch then flows to the large intestine, where it is fermented and produces lactic acid.



The increase in lactic acid lowers the pH of the hindgut, creating an extremely acidic environment in which beneficial resident bacteria die and release dangerous endotoxins. This cascade of events often leads to colic or laminitis. Hindgut acidosis is discussed further on page 35.

Like starch, **fat** is a useful energy source for performance horses. Fat must be reduced to fatty acids and then oxidized in the presence of oxygen to produce energy, or stored as body fat. Most fatty acids cannot be converted to glucose or used to synthesize glycogen. From a gross energy perspective, fat contains 2.25 times the energy per weight as carbohydrates, making fat incredibly energy-dense. Because of this, fat can be used to boost caloric content of a meal without increasing meal size, thus reducing the digestive and metabolic risks related to diets high in starch and sugar.

Fat is typically fed to horses through various vegetable oils, such as canola, coconut, corn, cottonseed, flax (linseed), peanut, rice bran, safflower, and soybean oils. Other fat-rich feedstuffs include stabilized rice bran, heat-treated whole soybeans, flaxseed, and black oil sunflower seeds.

Fat can be top-dressed in the form of any of the aforementioned feedstuffs. Because of the usefulness of fat in many diets, many fat-added commercial feeds are available. These concentrates typically contain 5-14% crude fat.

Unlike starch, the effects of feeding too much fat are less dire. Though horses are generally tolerant of fairly high-fat rations, especially if fat is introduced gradually, when fat creeps up too high, palatability suffers, and horses may refuse the meal.

Fat is often included in performance horse feeds because it is a "cool" source of energy, meaning many horses are less likely to get excited than if starch was used to provide a similar amount of energy. Controlled studies have confirmed this effect.

Much attention has been placed on readily **fermentable fiber** as an energy source for performance horses. As mentioned previously, horses possess a robust biome in their hindgut, a population of bacteria, protozoa, and fungi capable of fermenting large quantities of fiber. The products of fiber fermentation are used as a continual source of energy. Forage is the major source of fermentable fiber for the horse. Other fermentable fiber sources, sometimes called "super fibers," are processed by the hindgut like forages, but they have energy levels much higher than typical forages. In fact, their energy values are only slightly less than those found in cereal grains such as oats and barley.

The two most popular super fibers are beet pulp and soy hulls. Beet pulp is often used as an ingredient in commercial feeds, or added to a concentrate meal to boost the fiber and energy content of a ration. The seed coats of soybean seeds are called hulls and are much like the paper-thin skins that surround garden peas. In terms of digestibility, these feeds outrank traditional fiber sources. For instance, the fiber in hay is 40-60% digestible, depending on its quality, and beet pulp and soy hulls are 80% and 75% digestible, respectively.

The health of the gastrointestinal tract depends largely on continual forage consumption and processing, and readily fermentable fiber sources add another layer of safety to a diet already founded upon pasture, hay, or hay products, such as pellets or cubes, while providing an upshot in calories.

If the **protein** intake of a performance horse exceeds its requirement, the superfluous protein can be used as a source of energy. The amino acids, the building blocks of protein, from the extra protein are broken down by the liver, and the carbon skeletons that are left can be oxidized to produce ATP or used to make glucose or fat. The nitrogen from the protein is excreted in the urine as urea, which changes to ammonia as it interacts with environmental microorganisms.

FEED FORMS: IS ONE BETTER THAN THE OTHER?

Textured, pelleted, and extruded feeds can effectively deliver energy and essential nutrients to horses. Though horses will occasionally favor one feed type over another, the preference generally lies with the caretakers. Each feed form has attributes that owners should consider as they look for the best products to nourish their horses. Examining the pros and cons of each type of feed can clarify the decision and help with management strategies, but remember that feeds should be selected first on nutritional composition.

Forages, cereal grains, and seed meals all contribute to the protein requirements of performance horses. Forages are excellent sources of protein and amino acids, though the type of forage will determine protein quantity. Alfalfa, lespedeza, and varieties of clover are the most commonly fed legumes, and crude protein concentration of these is near 18-20% on a dry matter basis. Generally, grasses are lower than legumes in crude protein, containing 5-15% on a dry matter basis. Typical grasses include orchardgrass, Kentucky bluegrass, tall fescue, and timothy. Stage of growth affects crude protein content, as crude protein peaks when plants are in the vegetative stage and is lowest in late maturity. By and large, factors that affect total protein concentration will also affect amino acid concentrations in the forage.

Cereal grains, which are primary ingredients in typical commercial concentrates, supply horses with some protein: oats have 13% crude protein; barley, 12%; and corn, 9%. The protein in cereal grains is not considered high quality, meaning grains might not have an optimal complement of amino acids.

Various byproducts, typically called seed meals, provide high-quality protein to horses. Soybean meal, about 48% crude protein, is the most widely used seed meal because of its availability and desirable amino acid

profile. Feedstuffs with lower lysine content include canola, cottonseed, sunflower, safflower, and peanut meals, as well as dried green peas. While these can be used in concentrates, additional amino acids would likely be added to the formulation for optimal protein delivery.

Excessive protein should be avoided in the exercised horse for several reasons: (1) water requirements increase with excessive protein intake, and dehydration might become a concern if water is not consistently available; (2) urea levels increase in the blood, leading to greater urea excretion into the gut, which may increase the risk of intestinal disturbances; (3) the breakdown of protein produces more internal heat than the breakdown of other nutrients for energy, which can be a problem when exercising in heat and humidity; (4) increased ammonia in the environment from the urea excretion in the urine may have a harmful effect on respiratory tissues; and (5) protein is an expensive energy source, so feeds with higher protein often cost more than traditional formulations.

A blend of energy sources will reduce certain problems encountered by performance horses and will allow them to use energy generating substrates most efficiently during exercise.

CHOICES FOR EASY KEEPERS THAT PERFORM

Performance horses engaged in low-level exercise can frequently meet their energy requirements on diets composed entirely of forage. An all-forage diet, though, does not supply all of the nutrients necessary for optimal health. For these horses, a ration balancer provides a concentrated source of nutrients in a low-calorie pellet. Though recommendations vary among products, ration balancers typically are fed at 1-2 lb (0.45-0.9 kg) per day. One note about ration balancers: most contain a high percentage of protein, sometimes as high as 30%; this should not be a deterrent because the feeding rate is low. Feeding the recommended amount will fulfill protein requirements. Similarly, if a horse is engaged in occasional, low-level activity, a well-formulated vitamin and mineral supplement, such as Micro-Max™, might fit the bill.

Choosing A Performance Feed: The Tag Tells
A feed bag or tag often reveals clues to the usefulness of a feed to fuel exercise:

- *Feed name and purpose statement.* A reliable indicator of whether a feed is appropriately balanced for exercising horses would be the product name. If the name provides no indication of its suitability for performance horses, there should at least be mention of it in the purpose statement.

- *Various energy sources.* A well-formulated performance feed will supply energy from all three major dietary sources: starch, fiber, and fat. Review the ingredient listing to reveal that all sources are represented. Here's a key: starch is derived from cereal grains such as oats, corn, barley, and wheat; fiber comes from alfalfa meal, beet pulp, soy hulls, and to a lesser extent wheat middlings or bran; and fat is derived from vegetable oils, rice bran, and seeds such as flax or sunflower. Specialized feeds, such as those for horses with tying-up, might be low in starch but have adequate energy to fuel exercise, sometimes at the highest levels.

- *Check the guaranteed analysis for evidence of energy.* Because energy is a major concern for performance horses, it can be puzzling to calculate just how much energy a feed contains. In many countries, the amount of energy—measured as digestible energy, metabolizable energy, or net energy—is not required on the tag. When looking at fat, fiber, and protein values, the only one of these that is a direct indicator of calories is fat: the more fat, the higher the calories. Protein was previously thought to be a measure of energy but now is better understood to be an inefficient source of energy. Fiber is a tricky indicator of energy because the measure crude fiber" is not specific to how much is digestible and how much is indigestible. A feed could, theoretically, have wood shavings as a fiber source and have quite high fiber content but very low calorie content. On the other hand, if highly digestible fiber sources, like beet pulp and soy hulls, are used as fiber sources, the feed could have a high fiber content and be reasonably high in calories.

- *Close review of minerals and vitamins.* Chelated minerals are beneficial and can be an indication of a quality feed. They can be identified on the tag by seeing the name of a mineral listed together with the word "chelate," "amino acid," or "proteinate." Specific amino acids may also be listed. Vitamin E is an important antioxidant for muscle integrity and should ideally be at least 100 IU/lb. Natural vitamin E, which can be listed as such or as "d-alpha tocopherol," should be contained in the feed. Additives like probiotics or enzymes are usually found in more expensive feeds, and while they may not be essential for performance horses, they may add some value to the product, particularly for horses in high-stress situations.

- *Reputable manufacturer.* Products from reputable manufacturers will provide information about the feed, either on the bag or on the manufacturer's website. If actual ingredients (oats, corn, alfalfa meal) are listed rather than cumulative terms (protein products, roughage products, grain by-products, for example), then this is a good indication of a fixed formulation, which is most desirable, as it is best for a horse's health. Some manufacturers will change ingredients to meet the specifications promised on the guaranteed analysis, using whatever feedstuffs are least expensive. This is a problem, especially for sensitive horses, as one bag of feed might be very different from the next, despite having the same name and nutritional information.

SPECIAL HEALTH NEEDS REQUIRE SPECIALIZED FEEDS

Advances in research has led to the development of feeds useful for horses with health challenges. At the forefront are low-starch feeds, such as RE•LEVE®, originally designed by the nutritionists at Kentucky Equine Research (KER) for horses with myopathies such as recurrent exertional rhabdomyolysis (RER) and polysaccharide storage myopathy (PSSM). Low-starch feeds may also be useful for horses with behavioral problems and other issues.

FEEDING FATS TO PERFORMANCE HORSES

Energy requirements of performance horses are often best served by a medley of energy sources, and fat is extremely useful in fueling exercise and boosting calorie intake. Performance horses in heavy training may not be able to eat enough forage and concentrate to meet their high daily requirement for dietary energy. Because fat contains 2.25 times more energy per weight than carbohydrates, adding fat increases the energy density of the diet so that less feed is required. Additionally, fat is valuable when an alternative energy source to starch is needed, such as often required by horses with different muscle problems.

The natural diet of horses, namely forages, contains a minuscule amount of fat. Grasses and hays, for example, generally contain 1-4% fat on a dry matter basis. Horses are better able to digest fat than other livestock, such as ruminants like cattle or sheep, and tolerate up to 15% of the total diet as fat, although in practice that quantity is rarely fed. Most high-fat diets for horses are typically less than 10%.

Fat must be digested completely in the small intestine, and horses have little trouble processing reasonable quantities of fat. Most of the time the horse will let you know if there is too much fat by refusing to eat it. However, if too much fat passes into the hindgut, the microbial balance will be disturbed, leading to digestive disorders and interference with the absorption of some nutrients. Signs of too much fat in the diet include diarrhea or loose manure that possesses a soapy, gray sheen or film.

After the fat has been absorbed from the small intestine, the lymph system carries it to the liver, where its future use is decided. If the body needs immediate energy for muscle contraction, the fat is ferried in the bloodstream to muscle cells, where it is further broken down and used as an energy source. If the body does not need energy from fat at that particular time, it is stored in the muscle or in adipose tissue.

As with all changes to the horse's diet, the **introduction of fat** must be done gradually to allow the gastrointestinal tract to adapt. In the case of adding oil to a diet, for example, beginning with a quarter cup (60 ml) of oil, and then adding another quarter cup every four days will allow 1 cup (240 ml) per day to be fed by the end of two weeks. Some horses might have softer manure when oil is first introduced into the diet, but this will usually resolve itself as the gastrointestinal tract acclimates.

For the horse to be able to efficiently metabolize fat and use it as an energy source, there is also an adaptation period. When fat is used efficiently by the body it can have a glycogen-sparing effect, but this mechanism may take up to five weeks to become fully primed.

Dietary fat sources can be divided into two classes, liquid and dry supplements, and horses usually accept a variety of fat-rich feedstuffs.

Due to their widespread availability—not only at feed stores but also groceries and discount suppliers—vegetable oils (100% fat) tend to be the most popular fat supplements. Various vegetable oils are fed to horses, including canola, coconut, corn, cottonseed, flax (linseed), peanut, rice bran, safflower, and soybean oils. Top-dressing vegetable oils can disrupt the ration because it is only supplying one

nutrient, fat, so it is important to ensure that the that the diet also still meets the protein, vitamin, and minerals needs of the horse. If the horse is consuming at least the minimum recommended amount of a fortified feed in addition to the oil, the ration should be acceptable.

Most horses of average weight (1,100 lb or 500 kg) should consume no more than about two cups (16 oz, 480 ml) of vegetable oil each day; many horses have calorie requirements met by much less.

Dry fat-rich feedstuffs include stabilized rice bran, heat-treated whole soybeans, flaxseed, and black oil sunflower seeds (20-40% fat). These feedstuffs have less fat than vegetable oils, so if you choose to feed one of these dry fat sources, more will have to be fed for the same caloric benefit. Typical serving size for stabilized rice bran, for example, would be 0.5-2 lbs (0.23-.09 kg) per day, split between meals.

STABILIZED RICE BRAN

Stabilized rice bran is a natural, palatable source of high-quality fat. Although horse owners seem to be most interested in stabilized rice bran for its high fat content, concentrated source of energy, and other nutrients, researchers are investigating other potential health benefits. The antioxidant component, for example, is of particular interest because antioxidants help protect cells and tissues from damage following exercise and injury.

- Be certain to purchase stabilized rice bran. Unstabilized rice bran will go rancid quickly and can adversely affect health if consumed on a regular basis. It is also important to not confuse stabilized rice bran with other rice products available for equine consumption, such as broken rice.
- Ensure the rice bran is fortified. Unstabilized rice bran is naturally high in phosphorus and low in calcium. Calcium is added to quality products during stabilization to correct this imbalance.
- Choose a formulation, either a meal or pellet, that your horse accepts. Stabilized rice bran is generally palatable, but as with all supplements, start feeding stabilized rice bran slowly, gradually adding more every few days until the recommended amount is being fed.
- Consider consulting an equine nutritionist prior to instituting any dietary change, and discuss all components of the diet, including supplements, to ensure you are not oversupplementing one or more nutrients.

OMEGA MOVEMENT: LONG-CHAIN FATTY ACIDS FOR OPTIMAL HEALTH

Traditional equine diets of hay and grain tend to provide a skewed ratio of omega-3 and omega-6 fatty acids, underproviding omega-3s and oversupplying omega-6s. Cereal grains such as oats and corn, as well as many vegetable oils, are high in omega-6s, while hay and pasture provide omega-3s, despite being low in total fat content. Canola and soybean oil have an adequate omega-3 content, though still lower than the amount of omega-6 provided.

Too many omega-6s and too few omega-3s can result in excessive inflammation in the body. Therefore, having adequate amounts of omega-3s in the diet to moderate the pro-inflammatory response of the omega-6s is desirable. The most useful omega-3 fatty acids for conferring health benefits are docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), as they have the most biological activity.

Omega-3 fatty acids have been shown to reduce body-wide inflammation and to support immune function with specific applications for allergies, skin conditions, respiratory issues, myopathies, and exercise recovery. Reproductive benefits include improved fertility, enriched colostrum quality, enhanced passive transfer of antibodies to foals, and increased sperm concentration, motility, and viability.

Flaxseed and flaxseed oil provide alpha-linolenic acid to diets, which must then be converted to DHA and EPA in the body. Marine-derived sources of omega-3s, such as fish oil, are preferred because they provide DHA and EPA directly, with no conversion needed.

Average fatty acid composition of common feedstuffs. Omega values are a percent of total fat.

FEED	TOTAL FAT	OMEGA-3	OMEGA-6
Forages	3%	45%	19%
Cereal grains	3%	3%	30%
Corn oil	100%	2%	57%
Soy oil	100%	8%	54%
Canola oil	100%	11%	21%
Rice bran	22%	2%	34%
Flaxseed	40%	57%	16%
Fish oil	100%	24%	4%

Increase omega-3s in a horse's diet by (1) replacing corn, safflower, and sunflower oils with oils higher in omega-3 fatty acids, like canola or soy oil when extra calories are needed, (2) using a research-proven fish oil, such as EO•3®, when omega-3 supplementation is warranted.

High-fat commercial concentrates usually contain one or more of the aforementioned oil or dry high-fat ingredients, usually corn or soybean oil, rice bran, flaxseed, heat-treated soybeans, or a combination thereof. Concentrates with a significant amount of added fat can be identified from the guaranteed analysis, which will have a crude fat value of 6% or more. Most high-fat feeds will not be over 14%. The primary advantage of feeding a high-fat concentrate over top-dressing oil is that the commercial concentrate will be appropriately fortified with all nutrients for optimal health.

VITAMIN E SUPPLEMENTATION NEEDED FOR HIGH-FAT DIETS

During digestion, fat is broken down into its most basic structures, fatty acids. An increase in the amount of fat in the diet will therefore create an upsurge in circulating levels of fatty acids. Fatty acids are prone to oxidation, the byproducts of which can be harmful to cells. As a result, nutritionists typically recommended that an antioxidant be supplemented when a diet is high in fat, especially vegetable oil.

Though research is somewhat limited on the impact of high-fat diets in antioxidant requirements of horses, studies in other mammals suggest advantages in offering vitamin E. Giving 1-1.5 IU of vitamin E per 1 ml of oil will help minimize oxidative damage.

What does this mean, in practical terms?

Based on the recommendation of 1-1.5 ml of vitamin E per ml of oil offered, a horse fed one cup of oil (approximately 240 ml) should receive 240-360 IU of vitamin E per day above its normal requirement for added antioxidant protection.

Not all vitamin E supplements are created equally. In searching for a supplement to feed alongside oil, look for a natural-source vitamin E product. If you're unsure if a product contains natural or synthetic vitamin E, check the ingredient listing, which should state "d-alpha-tocopherol" for natural. Synthetic vitamin E, listed as dl-alpha-tocopherol on products, is absorbed less efficiently than natural vitamin E.

Peak antioxidant protection is provided through a water-soluble, natural-source product called Nano•E®, which features a unique nanodispersion delivery system that results in superior bioavailability.

NUTRITIONAL SUPPLEMENTS FOR PERFORMANCE HORSES

Most horses meet athletic demands and maintain body condition when fed a well-balanced diet consisting of forage and concentrates. Use of targeted **nutritional supplementation** can increase performance of horses with specific problems. Nutritional supplements for these problems are discussed in this chapter:

- Gastric ulcers
- Hindgut acidosis
- Electrolyte replacement
- Oxidative damage
- Joint health and integrity
- Vitamin and mineral support
- Hoof health and coat condition
- Bone strength

Gastric Ulcers

Maintaining gastrointestinal health is a prime consideration of the performance horse because, without a well-functioning digestive tract, horses will be unable to use nutrients supplied to them. With a volume of approximately 2-4 gallons (7.5-15 liters), the stomach of a 1,100-lb (500-kg) horse is not as capacious as one might think, especially considering the physical size of the horse or the total capacity of the gastrointestinal tract, which is about 37-50 gallons (140-174 liters).

Because of the horse's natural grazing behavior, there is little need for the stomach to be larger, as ingested feed does not remain in the stomach for long. In fact, about 75% of ingesta passes through the stomach within 30 minutes of consumption. As a horse chews, saliva is produced. Coupled with the continuous flow of ingesta, the natural buffering capacity of saliva keeps ulcers from forming in the stomach.

With nothing to chew, the horse produces little to no saliva. Sitting empty, the stomach begins to accumulate gastric acid and the mucosal lining of the stomach becomes compromised. Horses managed with long stretches between meals are therefore susceptible to gastric ulceration.

While some gastric ulcers go undetected and seem not to bother certain horses, other horses show a variety of clinical signs, including colic, diarrhea, poor appetite, dull coat, decreased performance, and even behavior changes.

A prescription-strength course of omeprazole will heal gastric ulcers, but over-the-counter supplements can keep ulcers

from forming initially or returning after treatment. Developed by Kentucky Equine Research, **RiteTrac**™ is a proprietary blend of ingredients designed to support total digestive tract health. Targeted to benefit the stomach and the hindgut of the horse, RiteTrac works in two distinct ways. First with its combination of fast-acting antacids and coating agents, **RiteTrac** quickly neutralizes excess gastric acid, protecting the stomach lining and restoring the normal gastric en-vironment. Second, **RiteTrac** contains **EquiShure**®, a time-released hindgut buffer designed to act in the cecum and colon by maintain-ing optimal pH, thereby reducing the risk of hindgut acidosis.

Hindgut Acidosis

The cecum, large colon, and small colon are often grouped and thought of as one entity, the hindgut. The cecum is home to billions of microorganisms that digest fiber. Through the efforts of these microorganisms, a great deal of energy is produced for athletic endeavors and maintenance of body systems.

The hindgut functions best when given the opportunity to regularly process fiber-rich feedstuffs like pasture, hay, haylage, and hay cubes. These feedstuffs keep the microorganisms well-fed and robust, and the balance of different microbial species in the hindgut remains optimal. When horses are fed large grain meals and minimal forage, the hindgut suffers.

Because the small intestine becomes overwhelmed when large grain meals are fed, ingesta passes to the cecum incompletely digested. Unfortunately, this starch-rich ingesta is detrimental to the cecum, often causing monumental shifts in the microbial population and affecting the pH of the entire hindgut. Fluctuating pH levels in the hindgut, called hindgut acidosis, can cause recurrent, low-level colic, behavioral issues, and certain vices such as wood-chewing and stall-walking.

Horses that do not require the stomach support offered in **RiteTrac**™ can be given **EquiShure**™ to stabilize the pH of the hindgut, allowing that portion of the gastrointestinal tract to work at its peak.

Electrolyte Replacement

Overall health and well-being of horses depends on many nutrients, including electrolytes such as sodium, chloride, and potassium. Forage contains high amounts of potassium, and when fed in adequate quantities, normally meets daily potassium requirements. In contrast, most forages are deficient in sodium and marginal in chloride. Concentrates supply horses with small amounts of these minerals as well. However, as a result of the many factors that affect intake and the rate of electrolyte loss, primarily through sweating, electrolyte supplementation should be provided to horses that exercise often.

Chronic electrolyte shortages can cause problems in athletic horses, including a decline in performance.

Restore® SR, an electrolyte supplement designed by Kentucky Equine Research, can be top-dressed on the daily grain ration to supply potassium, sodium, chloride, and magnesium. Sodium is provided through a proprietary slow-release mechanism, allowing it to be released gradually into the gastrointestinal tract for sustained absorption.

Electrolytes are sometimes added to drinking water, especially for heavily exercised horses. However, horses should be introduced to electrolyte solutions gradually and water intake monitored, as electrolyte solutions can result in reduced water consumption in some horses. If electrolytes are added to water, a bucket of plain water should also be available.

Similarly, addition of electrolytes to feed should be approached conservatively to avoid decreased feed intake.

Along with daily supplementation, administration of hypertonic electrolyte pastes such as **Restore Paste**™ before or during competition is widely practiced by endurance riders. Electrolyte pastes may contain a 50:50 mixture of sodium chloride and potassium chloride mixed with water. While salt pastes provide a portion of the electrolytes lost in subsequent work, another effect involves the stimulation of the thirst response. This encourages voluntary water consumption in order to maintain extracellular fluid volume during the ride and aid post-exercise recovery of fluid losses.

The use of furosemide in certain sports such as racing and barrel racing causes electrolyte loss and imbalance through increased urination. When coupled with the electrolyte losses that occur naturally with sweating, total electrolyte depletion can be significant following intense exercise. Without proper replenishment, complete physiological recovery may be delayed, setting the stage for longer intervals between races. **Race Recovery**™ provides targeted electrolyte supplementation for intensely worked athletes given furosemide, supporting a quick rebound from hard work.

Oxidative Damage

Oxidation is a normal metabolic process that allows horses to transform the carbohydrates, fats, and proteins they devour in meals to energy—energy to reproduce, grow, and perform. One unfortunate spin-off of oxidation is the creation of free radicals, compounds that have the potential to irreparably damage cells. Free radicals are particularly harmful to cell membranes, structures responsible for keeping destructive entities away from delicate inner organelles.

Under normal circumstances, substances called antioxidants thwart much of the wreckage caused by free radicals. However, oxidation speeds up during athletic effort due to increased oxygen consumption and accelerated aerobic metabolism.

During strenuous exercise, natural stores of antioxidants have difficulty providing sufficient protection against the cascade of free radicals generated from aerobic metabolism. Supplementation of antioxidants is therefore necessary to help ward off the ill effects of mass-produced free radicals associated with intense exercise.

Horses with an inadequate reserve of antioxidants may experience muscle soreness or stiffness during an exercise bout and prolonged recovery following hard work.

Vitamin E contributes most generously to the natural antioxidant defenses of the performance horse. Because of the irregularity in vitamin E content of forages and other feedstuffs, the nutrient is often added to fortified feeds. While synthetic forms of vitamin E had long been the standard source of added vitamin E in feeds and supplements, research has shown that synthetic vitamin E is not very effective at elevating vitamin E levels in blood. Natural-source vitamin E, depending on the preparation, is 1.6 to over 6 times as bioavailable as synthetic vitamin E and is therefore preferred.

Vitamin E is often linked with selenium, a micromineral that possesses potent antioxidant properties. Because it is an essential component of glutathione peroxidase, an intercellular enzyme that helps prevent the formation of free radicals, selenium is integral in the diets of performance horses. In addition to inadequate antioxidant defenses, a selenium deficiency may be detrimental to the muscular, reproductive, and immune systems.

Nano•E® is a revolutionary natural-source vitamin E supplement for horses. Liposome encapsulation and nanodispersion confer rapid and superior bioavailability for all horses, though especially important for performance horses. Developed by Kentucky Equine Research, Nano•E is an especially useful antioxidant for athletic horses without access to green grass for several hours a day.

Vitamin C, often referred to as ascorbic acid, also plays a pivotal role in neutralizing harmful free radicals. Because of its water-soluble nature, vitamin C can work both inside and outside the cell to combat free radical damage. In the exercising horse, perhaps the foremost contribution of vitamin C is its synergistic relationship with vitamin E. Once a molecule of vitamin E inactivates a free radical, its ability to short-circuit others is forsaken. In the presence of vitamin C, however, vitamin E can be regenerated to continue

its raid on free radicals. The rejuvenating properties of vitamin C, therefore, make it an essential ingredient in an effective antioxidant supplement.

Vitamin C is not included in the diets of most horses because the liver synthesizes sufficient quantities under normal circumstances. In periods of stress, such as during sustained exercise, vitamin C levels may drop and reduce the efficiency of antioxidant mechanisms in the body. In one study, endurance horses competing in 80- and 160-km races incurred vitamin C depletion, suggesting supplementation may be necessary to maximize antioxidant defenses.

Preserve™ PS contains a proven mixture of antioxidant agents and essential nutrients that supports normal muscle function during even the most strenuous exercise, and speeds muscle recovery after work, reducing downtime between performances. Preserve PS features natural-source vitamin E for superior bioavailability, selenium, and vitamin C.

Joint Health and Integrity

Performance horses place a lot of strain on their legs as they run, jump, spin, pull, or slide, causing cumulative wear and tear on joint structures over the years.

Some owners feed joint supplements to performance horses that have existing joint injuries in an attempt to expedite recovery. Similarly, in cases of arthritis or severe injury, joint supplements may allow horses to recover enough to become more comfortable and perhaps usable again. Others feed prophylactically, hoping to reduce the risk of injury from high-impact activities. Joint supplements are thought of as insurance against possible damage and are used in many top performance horses. Oral joint supplements generally contain one or more key ingredients.

Hyaluronic acid. A naturally occurring substance in joints and connective tissues, hyaluronic acid (HA) is produced by synovial membranes that line joints. It is the primary agent responsible for the viscous and lubricating properties of the synovial fluid, and has anti-inflammatory properties.

Regular turnover of HA in joints occurs. Research has shown that horses produce 30-160 mg of HA per day, which is incorporated into synovial fluid and cartilage. Inflammation resulting from exercise leads to a hastening in the breakdown of HA, which in turn causes reduced joint fluid viscosity and a vicious cycle of further inflammation.

HA has a very short half-life in horses, especially following intravenous injection, after which blood levels have been shown to return to normal within three hours. This rapid clearance of HA suggests that regular daily oral administration is useful.

The size of the HA molecule is measured in units called Daltons. Natural HA has a molecular weight of 1 million Daltons or more. Studies have shown that low-molecular-weight HA material does not have the same beneficial properties as natural or supplementary high-molecular-weight HA.

Due to the size of the molecule, absorption of HA is a considerable variable. The other issue is how absorption is measured. Oral dosing of radioactively labelled HA of one million Daltons in size has shown that there is uptake of HA into the joints of rats and dogs for up to 48 hours after a single dose.

Glucosamine. The most common ingredient in joint supplements is glucosamine, either as glucosamine hydrochloride or glucosamine sulfate. The former is a more concentrated and stable form of glucosamine, but they have similar biological effects. Glucosamine is an amino sugar that is the vital precursor to the synthesis of collagen and glycosaminoglycans (GAGs), including chondroitin sulfate and hyaluronic acid, in joint cartilage. Glucosamine can reduce GAG degradation and increase synthesis.

Glucosamine is thought to play a vital role in reducing inflammation by inhibiting gene expression for destructive enzymes. It also scavenges free radicals that cause inflammation and pain, and destroy the integrity of the cartilage matrix. The anti-inflammatory effect is a genuine modification of the disease process and doesn't act in an analgesic-only manner. Therefore, the end result may be reduced pain and increased joint mobility.

Glucosamine accumulates in cartilage and is detectable in synovial fluid for at least 12 hours after dosing. Researchers have found higher levels accumulate in inflamed joints than normal joints.

Glucosamine is very safe, making it suitable for long-term use, although care should be taken in pregnant horses and those with insulin resistance or equine metabolic syndrome.

Chondroitin sulfate. Chondroitin sulfate is the primary GAG that makes up the proteoglycans found in joint cartilage. Joint injury and the ensuing inflammation cause a reduction in the amount of proteoglycans. Thus, chondroitin sulfate theoretically could help replace proteoglycans, inhibit the action of some enzymes associated with cartilage breakdown, and offer anti-inflammatory properties.

Some clinical studies using a combination of chondroitin sulfate and glucosamine products have been encouraging. One study in old horses showed increased stride length and range of joint motion, as well as improved soundness compared to control horses that were not treated.

Joint supplements like **Synovate® HA** and **KER•Flex®** from Kentucky Equine Research can support joint health and extend the active years for many horses. **Synovate HA** delivers sodium hyaluronate, a structural component of joint cartilage and synovial fluid. **KER•Flex** contains glucosamine HCl and chondroitin sulfate and is designed to assist in maintenance of joint integrity. It may also slow the progression of arthritic changes in older horses.

Omega-3 fatty acids. Research in humans and many animals has shown that long-chain omega-3 fatty acids docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) have an anti-inflammatory

effect that can benefit joints as well as other parts of the body. Supplementing DHA and EPA in fish oil led to reduced markers of inflammation in the joints of both yearlings and older horses with arthritis. Another study found increased trot stride length in horses given DHA and EPA.

Vitamin and Mineral Support

Many horses in light work can maintain body weight on forage-only diets. Forages do not, however, contain all of the vitamins and minerals needed for optimal health and performance expectations.

To compensate for nutrient shortages in forages, a well-formulated vitamin and mineral supplement should be fed. **Micro-Max™** is a low-intake concentrated source of vitamins and minerals intended for mature horses. **Micro-Max** includes minerals that have been chelated or proteinated, processes that increase their digestibility and allow horses to derive maximum benefit from them. In addition, yeast culture is added to **Micro-Max** to enhance the digestion of fiber and other nutrients.

Obesity is a growing problem among performance horses. Unwanted effects of obesity include exercise intolerance, joint problems, and metabolic disorders. For those horses that can support body weight and exercise expenditures on all-forage diets, choose a scientifically formulated vitamin and mineral supplement such as **Micro-Max**.

Hoof Health and Coat Condition

Effective conditioning and training programs are of no use if a performance horse is sidelined with hoof problems. Regular oversight of hooves by a competent professional will waylay most potential problems. Certain horses simply do not grow strong, healthy hooves and this, in turn, can cause soundness problems. In these instances, supplementation becomes essential.

Key nutrients in hoof supplements include biotin, methionine, and zinc. Scientific studies have shown the benefits of biotin supplementation. Offering 15–20 mg of biotin per day improves hoof quality of many horses. Giving more than this each day does not yield additional benefits, though some manufacturers recommend more for severe cases of hoof compromise such as laminitis or recovering resections.

The same nutrients that improve hoof health also have a positive effect on hair coat, primarily because both are keratin-based structures.

Bio•Bloom™ PS is a dual-action supplement designed to promote and maintain healthy hooves, skin, and hair from the inside out. **Bio•Bloom PS** contains biotin, methionine, iodine, and chelated zinc at levels shown to improve hoof growth and development of a strong hoof wall. In addition, **Bio•Bloom PS** includes lecithin and essential fatty acids from full-fat soybeans, ingredients that are necessary for production of resilient hoof horn and shiny coats.

Bone Strength

Bone is a dynamic, living tissue strengthened through use. Impact stress from moderate exercise encourages osteoblasts to lay down osteoid tissue, which is converted into healthy, resilient bone.

When a horse does not exercise regularly, osteoids grow lazy, refusing to deposit substrate for skeletal renewal, and eventually mature bones will demineralize. Over time, demineralization weakens individual bones, which in turn reduces the strength of the entire skeleton. Studies have shown that horses kept on an exercise regimen have stronger skeletons than their stall-bound peers.

Stall rest is often a necessary evil as a horse recuperates from an injury. To some extent, supplements can combat the negative effects of extended stall confinement. **DuraPlex®**, a product is an effective mineralization supplement complete with a special blend of proteins, vitamins, and minerals.

For maximal skeletal resiliency, allow horses daily exercise, be it in a tailored training setting or just cruising in a pasture with friends. For those horses that must be kept confined, choose **DuraPlex** for long-term bone health and soundness.

NUTRITION-RELATED DISEASES OF THE PERFORMANCE HORSE

Advances in equine nutrition research have led to feeding strategies that can help horses overcome many challenges that can affect their athleticism. Manipulation of the diet has become commonplace in the management of these disorders:

- Recurrent equine rhabdomyolysis
- Polysaccharide storage myopathy
- Thumps
- Dehydration
- Anhidrosis
- Lameness
- Respiratory disease
- Exercise-induced pulmonary hemorrhage

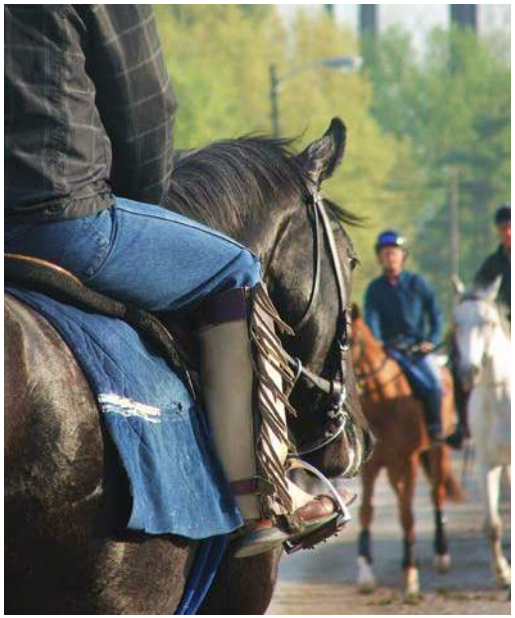
Recurrent Equine Rhabdomyolysis (RER)
A number of horses, predominantly fillies, have recurrent episodes of rhabdomyolysis (muscle cramping) with even light exercise. A wide variety of causes for RER have been proposed including electrolyte imbalances, hormonal imbalances, lactic acidosis, and vitamin E and selenium deficiencies.

Diagnosis
Although RER is occasionally seen in many breeds of horses, it is a common occurrence in Arabian, Standardbred and Thoroughbred horses. It most frequently occurs in young fillies with a nervous disposition. About 5% of Thoroughbred racehorses develop RER, often when they are trained at a gallop but held back from full racing speeds. Some highly susceptible individuals have repeated episodes resulting in persistent elevations in muscle enzymes serum aspartate aminotransferase (AST), creatine kinase (CK), and poor performance. In other susceptible horses, episodes may be intermittent. Stress and a period of stall rest preceding exercise appear to trigger RER in susceptible horses.

Lactic acidosis was previously believed to cause RER, and many treatments still used today (lactinase, DMG, sodium bicarbonate) are directed at resolving a lactic acidosis. Research has shown, however, that RER occurs most commonly with aerobic exercise, and that during an episode, affected horses have low muscle lactate concentrations and metabolic alkalosis. Research conducted in England suggested that a dietary deficiency of sodium or a low calcium-to-phosphorus ratio based on urine creatinine clearance ratios might contribute to RER. Subsequent studies showed that many of the Thoroughbred racehorses with chronic intermittent rhabdomyolysis had normal electrolyte ratios. Recently, an abnormality in muscle excitation-contraction coupling has been identified in Standardbreds and Thoroughbreds with RER. The altered relaxation of muscle following a contractile twitch in affected horses suggests that abnormal intracellular calcium regulation is the cause of RER. In addition, a recent study showed elevated myoplasmic calcium concentrations in horses with acute RER.

Guidelines for Feeding Affected Horses

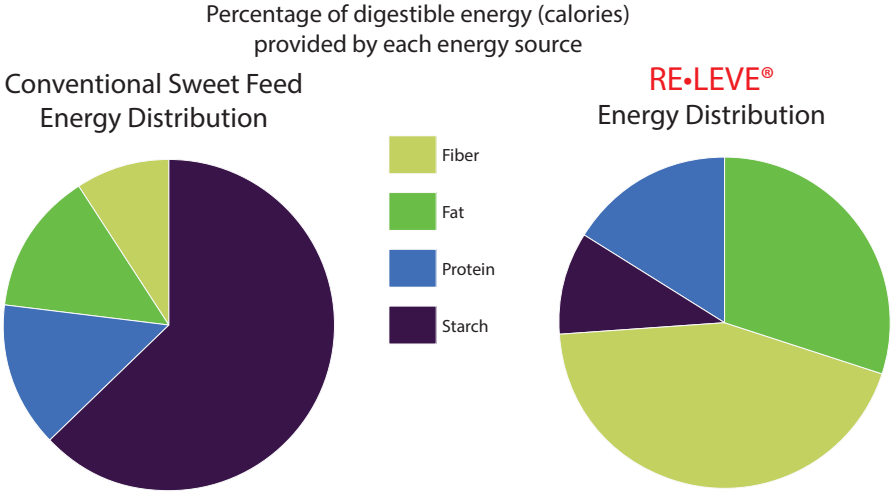
Prevention of further episodes of RER in susceptible horses should include standardized daily routines and an environment that minimizes stress, including provision of an appropriate diet.



Forage requirements. Because tying-up affects horses that are frequently subjected to moderate or intense exercise, high-quality forage should be fed to maximize the caloric contribution of forage. Forage may include either legumes (alfalfa or clover) or grass hays, and should be made available to horses at all times.

Concentrated energy. Feeds for horses diagnosed with RER should be chosen carefully. Although horses have individual thresholds for starch tolerance, it is best to eliminate much, but not all, starch from the diet of affected horses, keeping less than 20% of the daily digestible energy as starch and sugar. Extremely low-starch diets do not adequately fuel racehorses. Anecdotal reports suggest that diets with less than 8-10% starch and sugar may negatively impact performance.

Specialized feeds for horses that are intolerant to large amounts of starch or sugar are the most appropriate. **RE•LEVE® Original**, a low-starch, high-fat feed formulated by Kentucky Equine Research (KER), provides adequate energy to horses in the form of alternative energy sources, primarily fermentable beet pulp and vegetable oil. **RE•LEVE Original** is formulated to meet the energy and nutrient demands of horses with moderate to high energy needs. Most horses do well on 8-12 lb of **RE•LEVE Original** daily.



Supplemental oil. Adding oil to the diet is one way to boost caloric content, as all oils are completely fat. In light of the benefits proffered by omega-3 fatty acids, choose soybean or canola oil, as these are richer in omega-3s than corn oil. Between 0.25-2 cups of oil can be fed daily, though it should be added gradually over a period of a week or so. At the upper limits, palatability may become a problem, so be sure to divide the oil among meals and thoroughly mix it into the feed.

Antioxidant intake. The addition of fat to the diet could cause an upswing in the production of free radicals. To prevent cellular oxidation triggered by free radicals, RER horses should be fed a vitamin E supplement, the most potent of which is a natural, nanodispersed product called **Nano•E®**. Vitamin E should be offered at an intake of 1-1.5 IU per ml of supplemental oil in addition to 2-3 IU of vitamin E per kg body weight for horses in light work. An 1,100-lb (500-kg) horse, for example, should receive 1,000-2,000 IU of vitamin E per day.

Other Management Strategies

Exercise. Horses diagnosed with RER should be exercised regularly, and long periods of stall rest should be avoided. If a horse requires a break from training, try to provide turnout if soundness allows. Turnout should not be stressful, so time spent with a docile companion in a small area is best.

Environment. Horses diagnosed with RER are often high-strung, so every effort should be made to reduce stress whenever possible, and should include tactics to promote calm behavior. Through trial and error, caretakers can determine what is best for individual horses. Some affected horses like to be housed in stalls that afford a view of the hustle and bustle of the shedrow or barn, while others would rather be kept in a quiet corner. Because of their natural herd instinct, most horses like companionship, and that communion can come in the form of another horse or some ot do best on a routine, whi ties. Routine appears to reduce stress.

Polysaccharide Storage Myopathy

Among light horses, polysaccharide storage myopathy (PSSM) primarily affects Quarter Horses and members of related breeds such as Paints and Appaloosas. At its worst, the disease can be debilitating and often career-ending for ridden horses.

PSSM arises from two specific glitches in skeletal muscle metabolism. First, an abnormal accumulation of glycogen occurs in the muscle. As a polysaccharide, glycogen serves as the primary storage form of glucose in horses. While skeletal muscle is a major reservoir of glycogen, too much causes problems, including PSSM. Second, the presence of an abnormal polysaccharide may also occur in some horses with the disorder.

PSSM can be divided into two distinct types. Type 1 involves a mutation in the glycogen synthase-1 gene, which causes abnormal increased glycogen synthesis in skeletal muscles. Forms of PSSM that are not associated with this gene mutation are distinguished as type 2. Researchers have not yet been able to identify the cause for different forms of the disease in spite of biochemical studies.

The effects of PSSM manifest during exercise, usually 10 to 30 minutes after onset, and mirror many of those observed in other forms of tying-up. Mild signs include unwillingness to work, reluctance to engage the hindquarters, shifting lameness, and stopping and stretching as if to urinate. As pain increases, gaits frequently change, becoming stilted with a shortened stride, and muscles of the hindquarters become firm and sore. The most severe cases are characterized by profuse sweating, elevated respiration and heart rate, muscle twitching, refusal to move or only walk in a slow, wooden fashion, and off-colored, reddish-brown urine. Horses with extreme PSSM may be unable to stand.

A STEP AHEAD: MAKING ADJUSTMENTS PROPHYLACTICALLY FOR PSSM HORSES

Due in large part to the simplicity of genetic testing, horse owners no longer have to wait for an episode of tying-up to occur before management strategies are implemented. Regardless of the intended use of a horse, its diet can be designed to keep starch and sugar levels low while supplying all of the necessary energy and nutrients for top performance. In many instances, management strategies reduce the frequency of tying-up episodes, and sometimes clinical signs diminish entirely.

Diagnosis

Though the clinical signs of the disease are difficult to miss, the gold standard for diagnosis of PSSM remains muscle biopsy, as microscopic examination of muscle tissues reveals the presence of muscle damage with excessive normal glycogen (considered grade 1) or muscle damage with abnormal polysaccharide (grade 2). Muscle biopsies are not, however, easily obtained and require veterinary expertise.

Advances in genetic testing have allowed for diagnosis of type 1 PSSM through hair roots or whole blood samples. The American Quarter Horse Association offers PSSM testing as part of its five-panel genetic test. The Michigan State University Equine Neuromuscular Diagnostic Laboratory also performs genetic testing. Submission of samples is easy, and guidelines are provided on sample submission forms. Type 2 PSSM must still be diagnosed definitively through muscle biopsy.

Guidelines for Feeding Affected Horses

How best to feed a horse diagnosed with PSSM depends on the individual. Metabolism and performance expectations are two important factors in choosing an appropriate diet. Most horses with PSSM are typically in at least moderate body condition, and many are easy keepers bordering on obesity, so few PSSM horses require calorie-rich diets. Forage and feed choices for PSSM horses are centered on minimizing sugar and starch intake.

Forage requirements. Forage can be supplied as pasture, hay, or hay alternatives such as pellets or cubes. Well-maintained pastures should contain low-sugar grasses and few legumes (clover, alfalfa or lucerne). Grazing areas should not be lush, and low-yield acreage seems to be especially suitable for PSSM horses. If pasture suitability is questionable, pasture grasses can be analyzed by a reputable laboratory to determine if nonstructural carbohydrate (NSC) levels are less than 12%, which seems appropriate for most affected horses. In addition to the nutritional advantages of turnout, foraging allows for an increase in exercise, which is essential for these horses. For times when too much forage is available, a grazing muzzle can limit intake.

Hay and alternative hay sources such as pellets and cubes should be made from grasses and should also have NSC levels less than 12%. Appropriate hay is often mature. All hay should be free of mold, dust, and foreign material.

Concentrated energy. If a horse requires additional calories to maintain weight while exercising, a concentrated source of energy should be offered. Neither straight cereal grains such as plain oats nor textured or sweet feeds containing cereal grains should be fed.

Specialized feeds for horses that are intolerant to large amounts of starch or sugar are the most appropriate. **RE•LEVE® Concentrate**, a low-starch, high-fat feed formulated by Kentucky Equine Research (KER), provides adequate energy to horses in the form of alternative energy sources, primarily fermentable beet pulp and vegetable oil. **RE•LEVE Concentrate** is designed with greater nutrient density to ensure horses with low to moderate energy needs receive proper nutrients. Most horses do well on 3-9 lb (1.5-4 kg) of RE•LEVE Concentrate daily. If more than this is needed to maintain weight, choose **RE•LEVE Original**, which contains the same low-starch ingredients but allows more to be fed daily (6-20 lb, 2.5-9 kg), which boosts calorie intake.

Based on research conducted on **RE•LEVE**, the beneficial effect of a low-starch diet is believed to be the result of less glucose uptake into muscle cells and provision of more plasma free fatty acids for use in muscle fibers during aerobic exercise.

Balanced vitamins and minerals. Horses on all-forage diets require vitamin and mineral supplementation for optimal health. A ration balancer will make up for any shortfalls in protein, vitamin, and mineral nutrition, and will not add significantly to the NSC content of the diet. Most ration balancers are designed to be fed at a rate of 1-2 lb (0.45-0.9 kg) per day. In lieu of a ration balancer, a well-fortified vitamin and mineral supplement, such as **Micro-Max™**, can be fed if even 1 lb (0.45 kg) of a balancer pellet is too many calories for the horse.

Supplemental oil. Some studies suggest that signs of muscle dysfunction can persist even when horses are fed a low-NSC diet, but clinical signs diminish when even a little vegetable oil is added to the diet. For certain horses, additional calories in the form of vegetable oil might be necessary. In light of the benefits proffered by omega-3 fatty acids, choose soybean or canola oil, as these are richer in omega-3s than corn oil. Between 0.25-2 cups of oil can be fed daily, though it should be added gradually over a period of a week or so.

Antioxidant intake. The addition of fat to the diet could cause an upswing in the production of free radicals. To prevent cellular oxidation triggered by free radicals, PSSM horses should be fed a vitamin E supplement, the most potent of which is a natural, nanodispersed product called **Nano•E®**. Vitamin E should be offered at an intake of 1-1.5 IU per ml of supplemental oil in addition to 2-3 IU of vitamin E per kg body weight for horses in light work. An 1,100-lb (500-kg) horse, for example, should receive 1,000-2,000 IU of vitamin E per day.

Other Management Strategies

Exercise. Aside from a thoughtful diet, an exercise program must be implemented for PSSM horses to show clinical improvement, as it enhances energy metabolism. Horses with PSSM should have a well-defined and strictly enforced exercise program that includes daily paddock turnout and near-daily structured exercise, even if it is low-intensity work such as trail riding.

Return to exercise following a bout of tying-up should be slow but commence within a few days after all pain and stiffness has dissipated. Prolonged rest after an episode appears to be counterproductive, predisposing PSSM horses to further episodes. Similarly, too-rapid resumption of exercise could incite another episode of tying-up, causing further muscle damage.

Reintroduction of exercise to PSSM horses needs to be more gradual than approaches used in other forms of tying-up. Guidelines include: (1) providing adequate time for adaptation to a new diet prior to commencing exercise; (2) recognizing that the duration of exercise is more important to restrict than the intensity of exercise; (3)ensuring the exercise is gradually introduced and consistently performed; and (4) minimizing any days without some form of exercise.

Obesity. Many horses diagnosed with PSSM are obese. Owners can enhance fat metabolism in obese horses by riding them after a 5- to 8-hour fast as a means to elevate free fatty acids. Under normal circumstances, horses should not be fasted for this length of time as it sets the stage for gastric ulcers; however, supplementation with a proven gastric buffer such as **RiteTrac**™ may keep ulcers from developing.

Thumps

Body-wide electrolyte imbalance causes certain physiological peculiarities, one of which is thumps, known also as synchronous diaphragmatic flutter. The imbalance may occur because the horse loses large quantities of certain minerals, namely calcium, chloride, magnesium, and potassium, through extensive sweating or severe diarrhea, or because there is a problem with the way minerals are used within the body, such as kidney or parathyroid gland dysfunction.

Diagnosis

A horse with thumps looks alarmingly like a human with hiccups. In horses, spasms of the diaphragm cause marked, and sometimes convulsive, twitching of the flanks that mirror heartbeat. Though hiccups can be caused by any number of reasons in humans, the origin of thumps in horses can usually be traced to electrolyte imbalance.

The phrenic nerve controls movement of the diaphragm, the muscular sheet that separates the chest and abdominal cavities. Alkalosis resulting in low ionized blood calcium causes the phrenic nerve to become hyperexcited, spurring diaphragmatic contraction. Because the nerve runs over the right atrium of the heart, the excitability synchronizes diaphragmatic contraction with heartbeat.

Thumps is generally observed in fatigued horses, especially those that have sweated profusely during a bout of prolonged exercise. In severe cases, convulsions are so extreme that a thumping noise is produced, hence the name.

Horses that are fed a diet high in calcium, such as alfalfa, may be more prone to developing thumps during endurance competitionbecause the excess calcium in the body affects its ability to counteract losses during extended exercise.

Guidelines for Feeding Affected Horses

Treatment of thumps consists of electrolyte replenishment and, if severe enough, parenteral administration of calcium. Maintain electrolyte balance to prevent the problem during endurance exercise.

Routine electrolyte supplementation remains the best way to keep thumps from occurring. When significant electrolyte losses are anticipated, such as during an endurance ride or drive, electrolyte supplementation before, during, and after the ride is advised. For horses that have a diet high in calcium, it may be advisable to decrease the amount of calcium for at least a few days before the competition to stimulate normal calcium homeostasis.

Electrolyte losses go hand-in-hand with sweat production; if a horse sweats a lot during endurance work of one type or another, supplementation is warranted. If, conversely, a horse exerts little athletic output and thereby sweats minimally, few electrolytes will be lost and supplementation requirements will be lower.

A well-formulated electrolyte such as **Restore® SR** and **Restore Paste** delivers key electrolytes to horses, a necessary management strategy to avoid thumps.

Dehydration

Horses that are exercised during hot, humid weather lose fluid and electrolytes as they sweat. In very hot weather, even a fairly short exercise period can result in a significant fluid loss. Dehydration makes the horse's heart work harder and disrupts nerve and muscle action. In serious cases, it can lead to colic, kidney failure, and even death.

Diagnosis
Owners can use two simple tests to get a general idea of the horse's hydration status. The skin pinch and the capillary refill can both indicate whether a horse is adequately hydrated. Horse owners should practice these tests and become familiar with the result when their horses are in good condition.

As the horse loses water through sweating, its skin becomes less elastic. An owner can grasp a fold of skin on the horse's shoulder and pull it gently up into a slightly raised tent-like shape. In a horse that is somewhat dehydrated, the tented skin will remain raised for a couple of seconds before flattening out. If the horse's skin stays tented for more than four or five seconds, this can be a sign of serious dehydration. This test is not completely reliable, and results will be different between horses, but an owner familiar with a particular animal's normal state will be able to recognize an atypical result.

Capillary refill is another way to check hydration status. To do this test, the owner begins by pushing the horse's upper lip back to expose the upper gums. The gum tissue should be pink and moist, not too pale and definitely not dark brick-red, blue, or purple. Pushing a thumb against a section of gum and then removing the pressure will reveal a pale spot where the blood has been squeezed out of the capillaries. If a horse is properly hydrated, the small blood vessels will refill quickly, usually within a second or two. Anything longer than this is a sign that the horse has lost a lot of fluid or is possibly going into shock. Horses that don't seem to be recovering from hard exercise and show signs of dehydration that do not resolve quickly should be examined by a veterinarian.

Guidelines to Avoid Dehydration
Avoiding dehydration is a much safer plan than trying to resolve this dangerous occurrence. During extreme summer weather, riders should try to exercise horses early in the morning and should cut back on the duration and level of performance. Horses should be cooled after exercise by hosing or sponging with cold water, and should always have free access to water in stalls or pastures. Giving an electrolyte paste or powder formulated to replace the substances lost in sweat will help horses recover more quickly after strenuous exercise.

Restore® Paste, developed by Kentucky Equine Research (KER), stimulates thirst response and encourages horses to drink while supplying sodium, chloride, magnesium, and potassium. The paste is an easy-to-administer product that includes a buffering agent designed to support gastrointestinal comfort in horses. Daily electrolyte supplementation can be provided through **Restore SR**.

It may take several hours or even a day or more for a heavily sweating horse to rehydrate completely.

Anhidrosis
The sweat glands of most horses toil glitch-free for a lifetime, working tirelessly to moderate body temperature, excrete waste products, and help maintain the ecosystem of the skin. Occasionally, and often inexplicably, a horse will lose its ability to sweat, a condition known as anhidrosis. As with humans, sweating among horses is key to thermoregulation, so anhidrotic horses, sometimes called "non-sweaters," pose significant challenges for their owners.

The disease seems to be especially prominent in hot, humid climates, which makes the necessity of sweating all that more important. It can come on suddenly or develop slowly over time and is most often associated with times when the nighttime temperature does not go below 80° F.

Diagnosis
Researchers estimate that 2-6% of horses suffer from anhidrosis, though not all horses are similarly affected. Some anhidrotic horses have decreased sweat production, some have areas of the body that stop sweating, while others completely stop sweating. Anecdotal reports reveal that dark-colored horses are affected more frequently than light horses.

Aside from lack of sweating, an acute episode of anhidrosis is characterized by labored breathing, flared nostrils, increased heart rate, increased body temperature, fatigue and possibly collapse.

The greatest risk with anhidrosis is from the onset of heat stroke, which can be fatal if not dealt with immediately. Chronic cases are marked by increased drinking and urination, as well as a poor appetite. Horses with chronic anhidrosis might also have changes to their skin and coat, including dryness, scaling, regional balding, and itching, which is where another term for anhidrosis, "dry coat syndrome," originates. Impaired performance is a problem among those horses chronically affected. Those that do not sweat at all might be unable to work altogether because of their inability to cool themselves.

Guidelines for Supplementing Affected Horses
Some horses that begin electrolyte supplementation can be jump-started out of an anhidrotic state. Choose an electrolyte wisely. **Restore® SR**, developed by the nutrition specialists at Kentucky Equine Research (KER), provides innovative electrolyte therapy. Not only does it contain all of the important electrolytes—sodium, chloride, potassium, and magnesium—but it provides sodium in such a way that releases it slowly into the gastrointestinal tract, and this allows for sustained absorption. **Restore Paste** is also available and provides both oral and gastrointestinal comfort to sensitive horses that become irritated by traditional electrolytes.

While electrolyte and salt supplementation are an integral part of a treatment plan for anhidrosis, if the solution was as simple as just adding electrolytes to the diet, then horses would not be troubled by the disease. Though there may not be a cure for anhidrosis, there are other ways to address the problem that also help the horse deal with the issues caused by anhidrosis.

Some researchers believe supplementation with vitamin E might help anhidrotic horses. Natural-source vitamin E is superior to synthetic sources. **Nano•E®**, a natural-source product developed by Kentucky Equine Research (KER), features nanodispersion technology, which ensures rapid bioavailability.

Other Management Strategies

Additional management strategies, aside from moving the horse to a cooler climate, include:

- Provide access to a shady environment during the daylight hours, and use fans to keep air moving in stalls or run-in sheds. Air-conditioned stalls are helpful for maintaining a cooler body temperature. Water misters may also be used to keep horses cool in extreme heat.
- Nighttime turnout is recommended because there is more air movement and temperatures can be cooler than in stalls.
- Offer a source of cool, fresh water at all times.
- Exercise horses when temperatures are lower, such as in the early morning or late eventing.
- Dampen the coat with water before starting exercise. Allow for plenty of cool down time after exercise and monitor respiration rate. Splashing water on the neck, legs and body will help bring down the body temperature. Watch carefully fo any sign of heat distress.
- Aggressive, regular grooming stimulates blood flow to the skin. Keep the hair coat clipped regularly during the hot season.

Joint Health and Soundness

Performance horses put a lot of strain on their legs as they run, jump, spin, pull carriages, or perform sliding stops from a full gallop. Even the most placid trail-riding horses are asked to carry a saddle and rider for several hours. Though they may never go faster than a slow jog, this extra weight produces wear and tear on joint structures over the years.

Guidelines for Affected Horses

To keep your horse's joints in the best condition for a long riding career, follow these tips to preserve health and prevent discomfort or lameness.

- Good nutrition is a key to overall health in horses. Especially in young horses, feeding for smooth, gradual growth will help in the development of strong bones and healthy cartilage.
- Slow, steady training is important in keeping horses sound. Begin with short, easy exercise periods and increase the length and intensity of workouts over a period of several months. This type of conditioning allows the horse's muscles, bones, heart, and lungs to adapt to the

demands of performance. There is less chance of joint injury if the horse has the fitness level to perform without developing undue fatigue.

- Allow time for reconditioning after a layoff. If the horse is out of work for more than a few weeks, back off on the level of exercise when riding resumes. This is especially important if the horse is recovering from an injury or illness.
- Keep horses at an optimum weight. Obesity increases the stress on joint structures, eventually leading to unsoundness in some horses.
- Watch for early signs of joint problems such as heat, swelling, or lameness. If joint issues are diagnosed and treated in their initial stages, the chance for healing is enhanced and further damage may be avoided.
- Keep horses on a regular schedule of hoof care. Trimming and resetting of shoes will keep the hooves balanced, avoiding unnecessary strain. Corrective trimming and shoeing can also help young horses overcome conformation faults that put extra stress on knees, hocks, and fetlocks.

- Limit work on hard surfaces. Extreme concussion can damage joint cartilage, so riders should try to avoid long periods of galloping or jumping on hard, dry ground. For horses that are frequently ridden on pavement, such as in parades, padded boots can absorb some of the shock that is transmitted up the horse's legs with each step.
- Joint supplements like **Synovate® HA** and **KER•Flex®** from Kentucky Equine Research can support joint health and extend the active years for many horses. Synovate HA delivers sodium hyaluronate, a structural component of joint cartilage and synovial fluid. **KER•Flex** contains glucosamine hydrochloride and chondroitin sulfate, and is designed to assist in maintenance of joint integrity. It may also slow the progression of arthritic changes in older horses.

Respiratory Disease

Athletic horses are often beset by respiratory problems. Second only to musculoskeletal disease, respiratory compromise, when severe enough, can cut short the athletic careers of horses.

Diagnosis

One of the most common respiratory ailments diagnosed allergies among middle-aged horses is recurrent airway obstruction (RAO), a disease characterized by habitual cough and signs of respiratory distress that include flared nostrils, increased respiratory rate, and forced abdominal breathing. The horse may also appear anxious.

Inflammatory airway disease (IAD) is a term used among horsemen, particularly racetrack veterinarians, and refers to a mild variant of RAO. While RAO rarely affects horses under seven years old, IAD is predominantly diagnosed in young horses, those under five years of age.

Most horses diagnosed with RAO and IAD are stabled a portion of the day, fed large amounts of hay, and reside in temperate climates. Horses that graze outdoors year-round rarely, if ever, are afflicted by RAO or IAD.

The first clinical signs of RAO are usually observed following exposure to organic substances from hay and bedding during routine stabling. These substances, called allergens because they provoke an allergic reaction, include commonplace barn molds, forage mites, and endotoxins. Once inhaled by the horse, many allergens are minute enough to travel through respiratory channels and settle into the smallest airways of the lungs. As dust and mold deposit in the lower airways, an inflammatory response is mounted, which may include an accumulation of mucus in the airways, thickening of the tissues due to edema, and narrowing of the airways (also called bronchospasm). These changes in respiratory function may become worse in the presence of other air pollutants such as ammonia.

The severity of the disease depends largely on the individual allergic reaction of the horse. In mild cases of RAO, horses may appear normal at rest but cough or have nasal discharge during exercise. Horses with more advanced RAO typically have several clinical signs at rest; these may include frequent coughing, nasal discharge, increased respiratory rate, and increased effort in breathing. Forced expiration may result in overdevelopment of some abdominal muscles, eventually forming a "heave line." These horses will most likely be unable to perform even light exercise because their respiratory apparatus is incapable of delivering sufficient oxygen to arterial blood flow, which results in rapid fatigue.

Clinical signs of IAD, on the other hand, include low-grade airway obstruction characterized by cough and mild accumulation of pus within the airways. Unlike horses with RAO, IAD-afflicted horses experience a mild intolerance to exercise. The impairment, however, should not be downplayed, as it is usually sufficient to hinder performance of top-drawer athletes.

Diagnosis of RAO and IAD is typically based on history and clinical signs. Diagnostic testing can be performed on horses to ascertain the severity of the inflammation. Bronchoalveolar lavage has become the veterinary standard for collection of respiratory secretions. Similar to RAO, diagnosis of IAD is usually based on bronchoalveolar lavage. Other diagnostic techniques, including tracheal aspirate (also called tracheobronchial aspiration or tracheal wash), thoracic radiography, hematology, and serum biochemical examinations, have yielded little useful information.

Guidelines for Feeding Management

Forage requirements. Because horses are so often used for competitive riding, complete turnout may not be an option, though it is often the best scenario for horses with respiratory compromise. In mild cases, soaking the hay prior to feeding may be effective in reducing dust levels. Sprinkling the hay with water from a hose is not sufficient; hay must be drenched. One method is to place the hay into a clean and empty muck bucket and to fill the bucket with water, making sure all hay is submerged. The hay should then sit for 10 to 15 minutes, and should not be immersed in water any longer than 30 minutes prior to feeding, as water-soluble nutrients may be leached from the hay. Horses should be offered hay immediately following removal from the water.

Soaking hay daily is a labor-intensive chore. Alternative forage sources such as hay cubes, haylage, or completely pelleted feeds may be used instead of wet long-stem hay. These alternative forages may be dietary staples for horses with severe RAO. Horses must still be offered a small amount of long-stemmed roughage, but this requirement may also be met by several hours of pasture per day.

Concentrated energy requirements. Horses with RAO can be fed textured or pelleted concentrates that meet their energy requirements with no restrictions. In addition to increasing

palatability, molasses is often used to minimize the any dust in textured feeds, so there is very little dust associated with these products.

Supplemental nutrition. Horses with either RAO or IAD fed a nutritional supplement containing docosahexaenoic acid (DHA), an essential omega-3 fatty acid, such as **EO•3™**, benefit from daily supplementation. Specifically, after supplementation with the fatty acid supplement for two months, horses with RAO and IAD in one study had improved clinical signs of respiratory disease based on a 60% improvement in cough score and a significant improvement in lung function based on an almost 50% decrease in respiratory effort.

Other Management Strategies

To support respiratory tract health in horses, special attention must be paid to the quality of the air they breathe, even when they are at rest. Basic stable management to maximize air quality and support respiratory health includes the following steps:

- Dampen or soak hay that is fed indoors.
- Sprinkle the barn aisle with water when sweeping.
- Remove horses from barn during cleaning.
- Turn out horses as much as possible.
- Use a low-dust bedding with a daily mucking out.
- Consider ventilation during all seasons.
- Keep vaccinations up to date.
- Exercise horses regularly.

Exercise-induced Pulmonary Hemorrhage
Exercise-induced pulmonary hemorrhage (EIPH), also called bleeding, is a condition in which small blood vessels in a horse's lungs rupture during exercise. Blood may enter the pharynx, larynx, trachea, or bronchial tubes. In the worst cases, small amounts of blood may be seen dripping from the nostrils during and after races. Large amounts of blood can block the free flow of air into and out of the horse's lungs.

Most Thoroughbred and Standardbred racehorses are treated with furosemide before racing in the United States to prevent EIPH. Strong evidence supports the efficacy of furosemide to reduce the incidence of EIPH, and it is legal in most racing jurisdictions. Furosemide reduces the energy cost of exercise, which has given it a reputation as a performance-enhancer.

Though furosemide is an effective preventive for EIPH, it causes substantial loss of body weight. One disadvantage of furosemide is a delayed return to pre-administration body weight, with horses requiring three days to fully recover from lost weight. Further, furosemide causes a substantial loss of minerals, including a 40- to 50-fold increase in four-hour urinary sodium and chloride loss and a sustained calcium loss over several days.

Guidelines for Nutritional Management
The minerals that are lost as a result of furosemide administration can easily be replaced through proper supplementation. To improve weight recovery and replace these mineral losses, KER developed a two-stage electrolyte program called **Race Recovery**™. Race Recovery Paste is used immediately after racing and serves to stimulate thirst and hasten body-weight recovery. KER studies have shown that horses had a 17% increase in 24-hour water intake and a 30% improvement in body-weight rebound when given **Race Recovery Paste** compared to control horses.

Race Recovery Powder is fortified with highly bioavailable sources of electrolytes and minerals. KER balance trials have shown that **Race Recovery Powder** is effective in replacing electrolytes, including calcium and magnesium, lost in sweat and urine in exercised horses treated with furosemide.

COMMON NUTRITION-RELATED PROBLEMS IN PERFORMANCE HORSES

Nutritional strategies can be implemented to help with common problems of the performance horse, including:

- Excitability
- Laziness or lack of energy
- Lack of condition
- Obesity
- Inappetence

Excitability

From a behavioral aspect, nourishing a performance horse is a balancing act. The diet must provide sufficient energy to do the work asked of them and to maintain optimal body condition, but not provide energy in a form that causes nervous or excitable behavior. Most performance horses must be calm enough to focus on the job at hand. A docile, workmanlike manner is often rewarded in many competition venues.

Some horsemen link the amount of starch in the diet with an uptick in high-strung behavior. Research has suggested that diets low in starch and high in fat and fermentable fiber reduce reactivity, leading to a quieter demeanor, though horses respond to diets in individual ways.

Potential diet adjustments. To decrease starch intake, horse owners can look to the concentrate portion of the diet. Most feeds contain cereal grains such as oats, barley, and corn, all of which contain significant starch. To create low-starch feeds, feed manufacturers replace cereal grains with other calorie-dense feedstuffs, namely fat and fermentable fiber. Popular sources of fat include stabilized rice.

For excitable horses, also take a close look at forage selection. Alfalfa has often been thought to have a revving effect on the

temperament if a horse has a predisposition to being hot. There are more calories in alfalfa than grass hay, which is why alfalfa is helpful for adding and maintaining weight on a horse. Switching to grass hay from alfalfa may temper edginess.

Laziness or Lack of Energy

On the opposite end of the behavioral spectrum lie those horses that lack energy when being worked. Often, these horses are easy keepers fed diets comprised almost entirely of forages. All-forage diets balanced with a ration balancer is a sound way to nourish easy keepers, but these diets have a downside.

Potential dietary adjustment. Performance horses rely on muscle glycogen for energy. To build muscle glycogen efficiently, it helps to have starch in the diet. Cereal grains, such as oats and barley, are safe sources of starch, so one recommendation for a horse that lacks get-up-and-go is to add a small amount of oats to the diet. It doesn't take much; be careful not to add too much and contribute to weight gain. As little as 1-2 cups per day might noticeably increase energy under saddle.

Lack of Body Condition

With proper nutritional and health management, most horses can build and maintain condition. The effects of a weight-gain diet will reveal themselves in time, but don't expect immediate results.

Certain health problems make weight gain challenging, even in the best of circumstances. A veterinarian or equine dental specialist should examine the horse's mouth to ensure no dental anomalies are causing pain or malocclusion, which could make grinding feed difficult. A fecal egg count will determine if parasites have invaded the gastrointestinal tract, robbing valuable nutrients from the horse. Endoscopic examination of the stomach would reveal gastric ulceration, a common condition among horses with limited feed intake. If budgetary constraints preclude endoscopic examination,

a veterinarian can treat for ulcers with a course of omeprazole, and stomach and hindgut health can be maintained with **RiteTrac™**.

Potential dietary adjustments. Providing good-quality forage is the first step in designing a ration for a skinny horse. Full turnout on high-quality pasture remains a time-honored weight-gain strategy. Care must be taken to accustom a horse slowly to lush pasture if it was not in the field during the spring green-up. If pasture is unavailable, the next best bet is to choose an early-mature legume hay, one that has soft, pliable stems and an abundance of leaves. Such a hay typically contains more calories per mouthful than a good-quality grass hay. To verify hay quality, hay can be analyzed for nutrient composition. Give thin horses as much hay as they will eat, as a constant flow of forage through the gastrointestinal tract will keep it healthy.

To achieve weight gain, select a high-calorie concentrate, and preferably one that provides energy from a variety of sources such as starch, fat, and fermentable fiber. Many performance feeds contain this medley of energy sources—usually in the form of cereal grains, vegetable oil, beet pulp, and soybean hulls—as do some feeds marketed especially for senior horses. Choose a feed formulated by a reputable company, such as a KER partner. Be sure the feed contains a complete vitamin and mineral profile, preferably KER micronutrient fortification. Manufacturers provide recommended intake rates on feed bags; underweight horses might have to be fed at the top end of these recommendations. Keep individual meals at less than 5 lb. If necessary, divide the daily allowance into two or three meals.

High-calorie feedstuffs can be top-dressed to rations to increase energy density. The most common of these are vegetable oil and stabilized rice bran. Corn oil provides calories, but offers too many omega-6 fatty acids, especially when fed in combination with a high-grain diet. Soy and canola oil are two sensible alternatives.

Aside from weight-gain supplements, a hindgut buffer will keep the cecum and colon healthy, particularly when large quantities of grain and lush pasture are consumed. For this purpose, **EquiShure®** is recommended. The buffering action of **EquiShure** will ensure that the nutrients found in grain and pasture are digested appropriately. For total gastrointestinal-tract health, choose **RiteTrac™**, which includes both EquiShure and stomach protectants.

Obesity

Providing optimal nutrition for overweight horses challenges even the most dedicated of horse owners. With clear focus on the goal—that is, weight control—most horse owners can find a way to employ management tactics to keep the waistlines of their horses in check.

Possible dietary adjustments. Be cognizant of grazing time. Full-out grazing on good-quality pasture is counterproductive to calorie restriction. It is nearly impossible for a horse to lose weight, or even maintain it, when it has access to pasture all day. Consider short bouts of grazing a few times each day. One or two hours of grazing once or twice a day provides horses with the chance to forage and exercise, two important keys to physical and mental well-being. Being allowed freedom to exercise is much different than structured work, where playfulness is usually frowned upon. Because overweight horses are prone to metabolic diseases, choose grazing times wisely, ideally when sugar levels in pasture grasses are low, such as in the early-morning hours.

Using a grazing muzzle will allow a horse more time to roam, nip at grass, and socialize with peers. A good rule of thumb: a horse can double its time on pasture while wearing a grazing muzzle, as consumption is significantly reduced. Extra care should be given to proper adjustment of the grazing muzzle. If fitted too tightly, rubs may develop, leading to open sores; if fitted too loosely, the horse will find a way to escape from the muzzle and eat too much pasture, which could cause gastrointestinal problems.

Choose concentrates conscientiously. For overweight horses with low to moderate caloric requirements, feed selection should be centered on providing optimal vitamin and mineral nutrition, and this

often translates to a well-formulated ration balancer or vitamin and mineral supplement. Offering a fortified feed to overweight horses compounds the weight problem, supplying way too much energy for optimal health.

Horses on an all-forage diet should be fed a vitamin and mineral supplement to appropriately complete a diet, such as **Micro-Max™**, developed by KER.

A consistent exercise program of at least moderate intensity might increase caloric requirements, and an all-forage diet may no longer be sufficient to maintain weight. In this case, a fully fortified concentrate should then be fed, especially if a horse drops weight quickly and or has difficulty maintaining moderate weight. A horse's diet should be considered dynamic; as the horse's lifestyle changes, so too must its diet.

Hay selection is also a factor keeping weight ideal. Few horse owners mind paying for quality hay, as they understand that, as forage, it is the foundation of a healthy diet. Quality, however, is a vague descriptor, as hay that's suitable for one horse might not be suitable for the next, at least in terms of energy content.

For overweight horses, consider hay that was baled later than ideal (a telltale sign: fully formed seedheads) or that is comprised of a

mixture of common grasses rather than one or two predominant varieties. This type of hay contains less energy than premium hay, so it is most fitting for easy keepers. Even though the hay will be slightly less nutritious, it still should be free of dust, mold, foreign material, and unusual odors. Hay can be soaked in cold water for 30-60 minutes (or warm water for 10-30 minutes) prior to feeding to remove sugars.

Inappetence

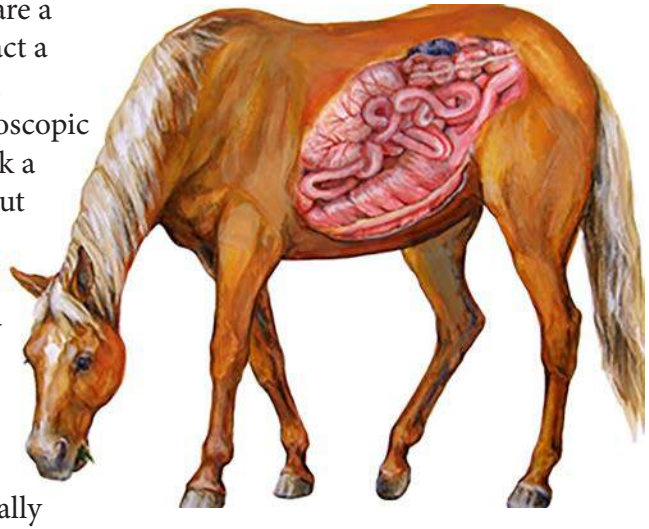
Many factors and situations affect a horse's appetite. Finding and correcting the cause of inappetence should be a foremost consideration. When horses do not eat enough to meet their energy requirements they lose weight, and when they refuse to eat the most nutritious ingredients in the feeder, they miss out on vital nutrients that can, in the long run, affect performance and health.

Sudden changes in feed. Any changes in feed should be made gradually, and this is doubly important with picky eaters. Changes are far less likely to be noticed if they are done slowly over a few days or weeks. Of greater importance, though, is the effect of sudden

changes on the health of the gastrointestinal tract. When new feeds and forages are introduced too abruptly, colic or founder may occur.

Mouth pain and discomfort. Causes of oral pain include broken, loose, or abscessed teeth, as well as wounds to the gums, cheeks, or tongue. Teeth should be checked at least once per year or as often as necessary. Some aged horses and horses with poor mouth conformation need more regular maintenance, which your equine veterinarian or qualified equine dentist can perform.

Gastrointestinal problems. Horses on high-grain diets and those not getting enough forage in their diets are prone to gastric ulcers. Horses in hard work, as well as those that become stressed during travel and competition, are at risk. Also in jeopardy are those that have had to be maintained on phenylbutazone for an extended period of time or that have not been eating and have had an empty stomach for hours.



If gastric ulcers are a possibility, contact a veterinarian and consider an endoscopic evaluation, or ask a veterinarian about treating for ulcers, which in itself can act as a diagnostic tool.

If ulcers are confirmed, treat accordingly, usually with omeprazole, then take measures to prevent the return of the ulcers, including adding more forage to the diet, reducing grain intake, and increasing energy intake from fat and fiber

sources. Once ulcers are cleared, horses should be offered a supplement proven to keep new ulcers from forming, such as **RiteTrac™**, which has the added benefit of containing a hindgut buffer to help combat hindgut acidosis.

Hindgut acidosis is a problem primarily with horses on high-grain diets and those with access to pasture with high fructan content. Hindgut acidity can cause discomfort and lead to reduced appetite. When this is coupled with diarrhea, weight loss can be profound and can happen quickly. The cause of acidity must first be established and removed or managed in order to amend the problem. If a high-grain diet is the cause, then reducing meal size and choosing heat-processed grains, such as corn and barley, rather than rolled or crushed grains to improve small intestine digestion should be the first step. Supplementation with a hindgut buffer such as **Equi-Shure®** can also help horses with hindgut acidosis.

Horses in hard work. As horses progress in their training, they sometimes lose their appetite. As they get fitter, they sometimes require greater more feed and less forage. Any sudden increase in work can simply turn them off their feed. Changes in hormones might also cause a sudden decline in appetite, so it is best to try and prevent this if possible. Make changes in work gradually. As feed needs to be increased, increase the number of meals rather than simply the size of the meal. Feed no more than 5 lb (2.2 kg) of feed in one meal. Be sure to provide plentiful forage, preferably as long-stem forage. Rather than automatically increasing just the grain when more energy is required, try adding more concentrated energy sources such as high-fat supplements so the overall volume of feed is not increased too much.

Illness and injury. Many equine illnesses are accompanied by anorexia or refusal of feed. Inappetence can be due to pain from an injury or general depression from illness. Though this is generally a temporary reaction, severely ill horses can have a poorer

prognosis if they go off their feed. Trying to increase the energy density of the feed and taking steps to encourage appetite can be of assistance in these cases.

If horses are hungry and all valid reasons for inappetence have been ruled out, they should eat what is put in front of them provided it is good quality, clean, safe, and designed to be fed in the manner you are feeding. It may take a few days or even weeks of persistence, but the horse will become accustomed to the feed and will follow his natural survival instincts. Many owners or managers wisely choose a period when their horse is out of work to introduce new feedstuffs, at a time when a slight loss in condition is of less consequence.

CHOOSE KENTUCKY EQUINE RESEARCH FOR SOUND NUTRITION RECOMMENDATIONS AND RESEARCH-PROVEN PRODUCTS

Kentucky Equine Research (KER) was founded in 1988 when Joe Pagan, Ph.D., realized that information generated from research did not reach the individuals who needed it most: feed manufacturers and horse owners. Since then the primary focus of the company has been bridging the gap between the research community and horsemen.

The company accomplishes this through research, consultation, and nutritional solutions.

KER is one of the most prolific private equine nutrition and exercise physiology research companies in the world. The quantity of published research derived from studies conducted at KER rivals that of leading universities. In addition to its own research, KER collaborates with prominent universities to develop and patent products and diagnostic techniques that target specific problems in horses of all ages and uses.

Aside from its research efforts, KER serves as an industry-wide consultant. At the core of the KER consultation services rests its Brand Alliance Partners, a collection of feed manufacturers dedicated to the production of high-quality feeds. The roster of Brand Alliance Partners continues to grow as feed manufacturers around the world recognizethe value added to their equine products through KER's research, technology, and credibility.

The advantages of purchasing a feed manufactured by a Brand Alliance Partner are numerous: expert formulation of feed designed specifically in the region or country in which it is to be fed, a complete understanding of trends in equine nutrition, and on-site consultation by leading equine nutritionists, just to name a few.

As a result of its research and consultation endeavors, KER has developed nutritional supplements to assist horse owners and managers in overcoming health problems. Many of these products are completely unique to the industry and provide nutritional solutions to common management problems.

Do you have a question about your horse's diet? Would you like one-on-one assistance in the formulation of a ration? Contact the nutrition advisors at info@ker.com.

For more information on Kentucky Equine Research, visit ker.com.

BODY CONDITION SCORES AND DESCRIPTIONS	
[1] POOR	Animal extremely emaciated; vertebrae, ribs, and hip bones projecting prominently; bone structure of withers, shoulders, and neck easily noticeable, no fatty tissue can be felt
[2] VERY THIN	Animal emaciated; slight fat covering over vertebrae; ribs, tailhead, and hip bones prominent; withers, shoulders, and neck structure faintly discernible
[3] THIN	Slight fat cover over ribs; ribs easily discernible; tailhead prominent, but individual vertebrae cannot be identified visually; hip bones appear rounded but easily discernible; withers, shoulders, and neck accentuated
[4] MODERATELY THIN	Slight ridge along back; faint outline of the ribs discernible; tailhead prominence depends on conformation, fat can be felt around it; hip bones not discernible; withers, shoulders, and neck not obviously thin
[5] MODERATE	Back is flat (no crease or ridge); ribs not visually distinguishable but easily felt; fat around tailhead beginning to feel spongy; withers appear rounded over; shoulders and neck blend smoothly into body
[6] MODERATELY FLESHY	May have slight crease down back; fat over ribs spongy; fat around tailhead soft; fat beginning to be deposited along the side of withers, behind shoulders, and along the sides of neck
[7] FLESHY	May have crease down back; individual ribs can be felt but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along withers, behind shoulders, and along neck
[8] FAT	Crease down back; difficult to feel ribs; fat around tailhead very soft; area along withers filled with fat; area behind shoulder filled with fat; noticeable thickening of the neck; fat deposited along the inner thighs
[9] EXTREMELY FAT	Obvious crease down back; patchy fat appearing over ribs; bulging fat around tailhead, along withers, behind shoulders, and along neck; fat along inner thighs may rub together; flank filled with fat

SELECTED REFERENCES

Kentucky Equine Research. 2015. Furosemide (Lasix® or Salix®) use in racehorses: A nutritional perspective. www.ker.com. (Accessed October 1, 2016.)

Kentucky Equine Research. 2016. Diet adjustments provide relief for PSSM horses. www.Equinews.com. (Accessed October 1, 2016.)

Kentucky Equine Research. 2011. Establishing work intensity in horses. www.Equinews.com. (Accessed October 1, 2016.)

Kentucky Equine Research. 2011. Five reasons to analyze horse forage and pasture. www.Equinews.com. (Accessed October 1, 2016.)

Pagan, J.D. 2007. Forage buffering capacity factor in gastric ulcers. Feedstuffs 79(54).

Pagan, J.D., 2010. Forages form basis for equine nutrient needs. Feedstuffs 82(14).

Pagan, J.D., 2007. Hindgut acidosis common in horses. Feedstuffs 79(31).

Pagan, J.D. 2011. Nutritional management of the horse. In: C.W. McIlwraith and B.E. Rollin, editors, Equine Welfare. Blackwell Publishing, Ames, IA. pp. 71-93.

Pagan, J.D., 2008. Omega-3s offer health benefits. Feedstuffs 80(13).

Pagan, J.D. 2013. Performance horses need more electrolytes. Feedstuffs 84(18).

Pagan, J.D., 2013. Tying-up manageable with diet, exercise. Feedstuffs 85(17).

Pagan, J.D., C.G. Brown-Douglas, and P.J. Huntington. 2012. Carbohydrates are well tolerated by most horses. In: Proc. Australasian Equine Science Symposium 4:1-3.

Pagan, J.D., B.M. Waldridge, C. Whitehouse, L. Dalgish, S. Fuchs, and M. Goff. 2013. Furosemide reduces the energetic cost of exercise in Thoroughbreds independent of its effect on EIPH. Journal of Equine Veterinary Science. 33(5):328-329.

Pagan, J.D., B.M. Waldridge, C. Whitehouse, S. Fuchs, and M. Goff. 2014. Furosemide administration affects mineral excretion in exercised Thoroughbreds. In: Proc. International Conference on Equine Exercise Physiology S46:4.

Whitehouse, C., J.D. Pagan, and R.J. Coleman. 2013. Responses in fecal pH from low to high starch intakes in healthy horses. Journal of Equine Veterinary Science 33(5):358-359.

Learn more by accessing Equinews.com.

Notes

Notes

Notes