Balancing act

A deficiency or an excess in the diet can impact health and performance

by Amy Gill, Ph.D., and Emily Hill

WHEN DEVELOPING rations for horses, especially those that are required to perform at the highest level, balance is crucial. From broodmares and young, growing horses to racehorses on the track, nutritional requirements for digestible energy (energy) or calories, protein, vitamins, and minerals must be considered. A deficiency, or in some cases even an excess, in any one of these areas could prevent a horse from performing to the highest standards.

Recognizing, correcting, and monitoring dietary requirements in a farm's or stable's feeding program is one way to ensure every horse has the opportunity to reach its greatest potential.

Energy requirements

When deciding what products to feed a horse, the initial concern often is whether the feed will supply adequate levels of energy. Ensuring that energy levels are sufficient to support the type of performance desired of the horse is an important consideration. Consistent monitoring of the ration will help prevent either an excess or a deficiency.

Carbohydrates and fats in the diet serve as the main energy sources that drive the metabolic activity required for maintenance of body systems, as well as growth, lactation, and physical activity. Hydrolysable carbohydrates are those that are broken down by enzymes in the small intestine, producing glucose as a source of quick energy, while soluble fiber is a structural carbohydrate that is fermented more slowly by the microbes of the hindgut.

Fats provide a more dense energy source, offering approximately 2.25 times more energy than carbohydrates.

The majority of ingested feed is utilized for energy production; other components are utilized for various biochemical processes, such as protein or lipid synthesis (protein, vitamins, and minerals are used in these processes).

Energy deficiency

Generally, an energy deficiency first will result in lethargy or reduced performance, and a reduction in physical activity, growth, or even milk production in lactating broodmares may be noted. More severe consequences are seen as the deficiency progresses, leading to weight loss and eventually a state of starvation. Without proper energy supplied directly through carbohydrates and fats in the diet, the body will turn to sources of stored energy.

Glycogen, the stored form of glucose in muscle or the liver produced through carbohydrate metabolism, is expended quickly, and then adipose (fat) stores throughout the body are utilized. Both glycogen and fat are sources intended for energy production. So at this early stage of deficiency, there is minimal impact on internal body systems. With continued lack of dietary energy, the negative impacts become much more evident.

Protein is not intended for use as an energy source, but once all other means have been exhausted, protein is drawn from the body in an attempt to meet its basic energy needs. Utilizing protein as a source of energy in this manner eventually will affect digestion and absorption in the gastrointestinal tract; decrease immune, respiratory, and cardiac function; and, finally, lead to degeneration of skeletal muscle.

Hydrolysable carbohydrates are those that are digested in the small intestine resulting in glucose, an easily utilized source of energy. However, this type of soluble carbohydrate needs to be monitored in the diet because excessive amounts could cause problems, just as an energy deficiency could.

Sugar 'high'

Horses are extremely sensitive to rapid and sustained increases in blood glucose following a meal. Fractious behavior often is an unwanted result of feeding concentrates high in hydrolysable carbohydrates (feeds that contain high concentrations of starches and sugars). Because horses tend to compensate for extra energy by expending more of that energy, behavioral problems may result from a horse too "hyped up" on starches and sugars.

Also, feeding large amounts of hydrolysable carbohydrates can cause acidosis in the horse's hindgut, a condition that can lead to colic, laminitis, and other metabolic disorders. It also has been linked to developmental disorders in growing horses. Therefore, nutritionists now recommend that energy sources utilized for horse feeds contain higher amounts of fats and soluble fibers, which provide ample energy without the concurrent rise in blood glucose following a meal or the possibility of acidosis.

Excessive energy in the diet also will result in fat deposition. Extra energy is stored in the body as adipose tissue, which may lead to obesity and decreased performance. Overweight horses often experience increased sweating and respiratory problems when worked, and they are at a higher risk for joint problems. The stress of added weight on a joint may lead to inflammation of the joint tissues and potentially a degenerative condition. Obesity in horses recently has been recognized as a predisposing factor in the development of insulin resistance.

Change diet gradually

Correcting diets that are deficient or excessive in energy requires slowly modifying the energy content of the total ration fed to the horse. When deficiencies occur, a determination needs to be made as to whether more feed should be offered or if a more energy-dense feed should be introduced. Any change to the diet—either increasing feed or introducing a completely new feed—must be made slowly over a period of seven to ten days to prevent digestive upset (colic or diarrhea).

Before changes are made to the concentrate portion of the ration, the quality and quantity of the forage being offered should be analyzed. Alfalfa or legume hay has a significantly higher calorie content than typical grass hay, such as timothy, and should be considered as a means of increasing energy in the ration. Other types of forage, including oat, wheat, and barley hays, are good alternatives for certain horses and are growing in popularity.

Oat hay is an very palatable forage, providing the nutrients required by mature animals but lacking the quality of protein required for young, growing horses. While oat hay is a viable option for mature horses, wheat hay provides higher levels of protein, which makes it suitable for mature and young horses alike.

If a high-quality forage already is a part of the daily ration and is still not providing sufficient levels of energy, a more calorie-dense concentrate may be introduced.

Excessive energy is corrected in a similar way, by either reducing the concentrate offered to the horse or offering a lower-energy feed. To sustain healthy microbes in the hindgut, forage never should be limited in the diet below 1% of a mature horse's body weight per day (the preferred level is 1.5% to 3% of body weight, depending on age and level of work). Care needs to be taken when reducing the intake of an overweight horse to ensure that the animal is still receiving adequate levels of protein, vitamins, and minerals in the feed.

Amino acid requirements

After energy requirements are defined for a class of horse, the next nutrient to consider is protein. Proteins are composed of numerous amino acids linked together in an order determined by the type of protein and its intended use. Dietary protein is broken down into individual amino acids that are reorganized and synthesized into the specific proteins needed by the body.

Meeting a protein requirement does not mean just supplying a certain amount of crude protein; it means ensuring levels of specific amino acids, as well. Certain amino acids are unable to be produced in the

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horse's body tissues and must be provided through the diet. These are referred to as essential or limiting amino acids, the most important of which is lysine, followed by methionine and threonine. These amino acids, along with others produced by the horse, are used in structures throughout the body.

Proteins also function as enzymes that increase the rate of various metabolic reactions, as well as antibodies aiding immune response. Collagen, a structural protein, forms the basis for connective tissues, including ligaments and tendons, along with the cartilage that protects the ends of bone to provide a cushion within the joint.

Protein deficiency can manifest itself in several ways. Mature horses may experience a poor hair coat, decreased performance, and possible weight loss; broodmares may fail to produce enough milk to adequately supply their foals.

Young horses could potentially suffer the most severe repercussions when protein is lacking in the diet, including decreased or poor-quality growth, which potentially could lead to future orthopedic problems.

Adjusting a diet lacking in the required amino acids means finding feeds or alternative ingredients with a higher protein quality, or greater concentration of essential amino acids. Both soybean meal and milk proteins provide excellent quality protein with the amino acids necessary to adequately complement the horse's requirements. A good quality, fortified concentrate also will supply the horse with the limiting essential amino acids, guaranteed levels of which can be found on the feed label. Labels should include a guaranteed level of lysine and methionine. Some feeds now list threonine content, as well. With the addition of guaranteed levels of amino acids on feed tags, evaluating the quality of a concentrate's protein and determining whether it will be adequate for the growing horse, broodmare, or high-end performance horse is now easier.

Vitamin requirements

With energy and protein balanced in the diet, vitamin and mineral requirements become the next area of focus. Vitamins in the body serve as antioxidants and are necessary for several metabolic processes, often acting as catalysts in biochemical reactions. These organic compounds are classified as either water- or fat-soluble, depending on how they are absorbed and stored within the body.

Water-soluble vitamins are dissolved easily in water and, therefore, are quickly excreted from the body on a daily basis; fat-soluble vitamins are absorbed through the gastrointestinal tract with the help of lipids (fats) and can be stored in body tissues.

B vitamins and vitamin C are water-soluble, and because of their relatively quick excretion, they are not stored within the body. On the other hand, vitamins such as A, D, E, and K are fat-soluble and are stored.

The horse is able to produce vitamin D through a process that involves absorbing ultraviolet rays from sunlight into the skin; vitamin C is synthesized from glucose in the liver; and niacin, a B vitamin, is produced by converting the amino acid tryptophan in the liver. Microbes in the hindgut manufacture the remainder of the B vitamins, along with vitamin K. Therefore, the only vitamins the horse theoretically requires from dietary fortification are vitamins A and E, but all these vitamins are routinely added to horse feeds.

The fortification of concentrates and supplements fed to horses above and beyond maintenance requirements is common practice because high-level performance horses, broodmares, and growing horses will benefit from added supplementation.

Despite the extreme importance of vitamins, they are not required in great amounts. In fact, fat-soluble vitamins are stored in body tissues and, consequently, may actually reach a toxic level if provided in extreme quantities. Though toxicities and deficiencies with regard to vitamin requirements are not common in horses that are fed quality forages and well-formulated concentrates, it is important to detect the early signs that may be indicative of a problem.

The clinical signs of vitamin deficiencies are dependent upon the vitamin in question:

- **Vitamin A:** Inadequate levels of vitamin A will result in decreased appetite and growth, increased respiratory problems, tearing eyes, weakness, poor-quality hair coat, and a lowered conception rate in broodmares;
- **Vitamin D:** Deficiencies in vitamin D will produce a similar reduction in appetite and growth;
- **Vitamin E:** In tandem with selenium, vitamin E acts as an antioxidant, removing free radicals and protecting body tissues, which is extremely important in the intensively trained horse. Inadequate supply of vitamin E, selenium, or both can result in decreased immune response. As the deficiency becomes more significant, it may cause muscle damage (myopathies) or inflammation of adipose tissue (steatitis), most commonly seen in foals. Insufficiencies of vitamin E in utero could result in generally stiff or weak muscles in the foal or the development of white muscle disease; and
- **Vitamin K:** Insufficient vitamin K reduces the blood's ability to clot because its function is to activate clotting factors.

Mineral requirements

Minerals are inorganic elements used for bone structure and as enzyme components needed to accelerate various biochemical reactions, including nerve conduction and muscle contraction. Macrominerals (calcium, phosphorus, sodium, magnesium, chlorine, potassium, and sulfur) are required in large amounts from the diet. Microminerals, or trace minerals, are not required in high concentration. Trace minerals include selenium, copper, zinc, iodine, manganese, cobalt, and iron.

When it comes to mineral requirements, levels of specific minerals are important, but equally as crucial is their ratio to one another. If one mineral is supplied in excess and is not absorbed, it may bind to another that just meets minimum requirements, preventing its proper utilization. Ultimately, this means that a horse could be receiving an adequate level of a specific mineral, but the imbalanced ratio results in a deficiency. For example, calcium and phosphorus ideally should be supplied in a ratio of 1.5:1 and no less than 1:1. The reason for this is that a molecule of calcium must be linked with a molecule of phosphorus in order for absorption to occur. If there is no calcium to be linked with an available molecule of phosphorus, it will be drawn out of the bone, which, over time, will lead to decreased bone density and strength.

A similar relationship exists between calcium and magnesium. Magnesium is generally received in adequate amounts from the typical equine diet, but many supplement the horse's diet with this mineral to calm a nervous horse. When calcium and magnesium are fed in ratios of less than 2.5:1, the excess magnesium negatively affects the absorption and utilization of calcium. Therefore, it can be concluded that adding excessive amounts of vitamin and mineral supplements to an already balanced ration is generally unnecessary and in some cases can cause interactions that negatively affect the health of the horse.

Minerals are of extreme importance to bone development in growing horses. Calcium, phosphorus, copper, and zinc are crucial in the mineralization process, which begins during fetal development and continues generally until age three. This biochemical process of incorporating calcium and phosphorus directly into bone utilizes copper and zinc as enzymes, or catalysts, in the reaction.

Copper also is necessary for the synthesis and employment of collagen and elastin, the primary components of connective tissues. Without sufficient amounts of these minerals in the ration, young horses may suffer from inadequate bone development, leading to decreased bone density and increased risk of developmental orthopedic diseases.

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