

# Protein, fat, and carbs

Dietary sources provide nutrients for protein building, biological processes, and energy metabolism

by Amy Gill, Ph.D.

**A** RACEHORSE'S diet comprises harvested grass and legume forages, concentrates fortified with dietary protein, vitamins, minerals, salt, water, and various supplements. Occasionally, a small amount of grass is available if the horse is hand-grazed or turned out in a paddock.

These food sources provide nutrients for building hundreds of different types of proteins, including bone tissue, blood proteins, and muscle, and for building fats and carbohydrates to drive metabolism and contract muscles.

The role of these three classes of nutrients can be somewhat confusing to a horse owner, largely because the feed industry in the past has marketed feeds based on the percentage of their protein content, with little acknowledgement to the inclusion rates of fats, sugars, starches, and fiber that contribute to calories, vitamins, minerals, and other nutrients in the feed.

Because of the lack of information on the feed label or tag, many people assume the protein percentage

to be a gauge of the feed's energy content. This assumption is incorrect because protein in the feed is provided to supply the horse with amino acids, which are used to form other proteins, while fat and carbohydrates provide calories or digestible energy to drive the biological processes, including formation of proteins. The percentage of protein has little to do with the actual calorie content of the feed, but generally the higher the percentage of protein, the more energy-dense the feed because higher-protein feeds are formulated specifically for horses that are breeding or engaged in intense work.

The use of high-protein, high-energy feeds can lead to increased nervous activity in a horse if the amount of energy expended does not coincide with the amount of energy consumed. Additionally, some studies in humans and dogs have shown that the specific amino acid profile in the diet can be manipulated to reduce behaviors such as aggression and hyperactivity. From this information, it may be concluded that the quality of protein and the specific

amino acids available to the horse are more important than the percentage of protein in the diet.

Demystifying the relationship between dietary protein, fat, sugar, starch, and fiber will provide a clearer understanding of how a horse uses these nutrients. By understanding the role of nutrients, owners and trainers should be able to make educated decisions about which products to feed their horses.

## Proteins to make other proteins

Proteins are sometimes called the building blocks of life, and when new tissues are made, large amounts of dietary protein are required. The stages in an animal's life when new tissues are extensively manufactured are growth, lactation, and pregnancy.

Proteins are composed of units called amino acids. Proteins are synthesized from available amino acids that are ingested or synthesized by the horse and used to build muscle and bone, blood components, enzymes that catalyze biochemical reactions, hormones, peptides, and antibodies. Twenty different amino acids are needed for protein synthesis, and several can be made by tissues of the body. However, these ten amino acids must be supplied to the horse through dietary sources: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Lysine is the amino acid that is often in shortest supply in horse feeds and is particularly important for growing horses. Because feed ingredients used for horse rations can be deficient in some amino acids, several feed companies are now adding lysine, methionine, and threonine directly to the formulation of a supplement or concentrate in addition to the protein source in the product. This is important because if one amino acid needed for protein synthesis is in short supply, that protein cannot be formed. In growing horses, this can lead to poor-quality growth and developmental diseases; in working horses, it can cause poor body or muscle condition and possibly

bone breakdown.

If necessary, the horse also can use protein as a source of energy during starvation or intense exercise by removing the amino group (the nitrogen portion of the molecule) and using the carbohydrate skeleton that is left for energy production. Starving horses or protein-deficient horses will catabolize muscle tissue to produce amino acids for other biological processes.

Even though protein can be used as an energy source at certain times or when excess protein is fed, it is an expensive ingredient in horse feeds and should be fed in the correct amount. Fats and carbohydrates are used preferentially as a substrate to produce energy for metabolic processes and during exercise and should be fed in balanced amounts along with protein so that protein is not used as an energy source.

Excess protein is broken down into urea and must be excreted in urine. This process requires water, and horses fed excess protein not used to make other proteins will consume larger than normal amounts of water. The result is a very wet stall and production of ammonia, as the urea is converted into ammonia by bacteria on the stall floor. Ammonia is a strong respiratory irritant and can be a source of tremendous irritation in stabled racehorses.

The metabolism of protein also produces a lot of internal heat, which can contribute to heat stress, especially in horses working in hot, humid weather. Excess protein in the diet is not a problem for healthy horses to metabolize and will not lead to kidney or liver disease, but horses with kidney or liver failure should be fed minimum protein requirements.

Exercise does not require an increase in the protein percentage in the diet of a mature horse but rather in the total amount of protein fed. For example, an idle, mature horse that is being fed five pounds of a ration that is 10% protein would continue to receive the 10% protein level once put in training, but the total amount of feed used to maintain body condition of the horse would be in-

creased. By simply increasing the amount fed, the total amount of protein given increases and will be sufficient to meet extra protein needs due to exercise.

## Correcting beliefs about proteins

Certain misconceptions exist about proteins. One concerns "protein bumps" or hives that occasionally develop on the skin. More often than not, these bumps can be attributed to the result of skin contact with some chemical in the bedding or consumption of a noxious weed. Less frequently, an allergic reaction of the body to foreign proteins in the feed causes the bumps.

Insect bites and heavy periods of rain also can cause hives. Skin bumps or hives generally resolve on their own after a few days, but if they persist or break open, a veterinarian should be consulted.

High-protein rations also have been implicated in diseases such as epiphysitis and osteochondritis dissecans (OCD). These problems are associated with fast-growing foals that are typically on high-protein, high-energy rations that allow them to grow quickly. However, it is now recognized that in addition to high levels of energy that accelerate growth rates in young foals, rations with significant starch content can cause a shift in hormones associated with bone growth and may lead to developmental disorders. Other factors, such as balanced vitamins and minerals and quality of protein in the diet, are essential for proper bone development.

As mentioned earlier, if amino acids are limited in the diet, some protein formation may be limited, leading to poor-quality growth and condition as well as a variety of diseases. The addition of amino acids to concentrates greatly enhances the quality of growth and performance in horses.

## Protein sources

Dietary recommendations for feeding quality protein sources include:

- Using excellent-quality forages with adequate levels of protein for

## Protein requirements for a horse's life

**Growth:** Horses grow most rapidly from birth to six months of age. Growth slows between six and 12 months. Horses fed adequate protein will have achieved 80% of adult size by 12 months of age. If the protein level in rations for young, growing horses is inadequate, normal growth cannot occur. Protein-deficient growing horses are not thin, but they will not reach their genetically predetermined adult height

**Pregnancy:** A mare in the first two trimesters of pregnancy requires maintenance-level protein in the diet (8% to 10% good-quality protein). Starting in the last trimester of pregnancy, she should be adapted to the same ration she will be fed during lactation.

**Lactation:** Milk contains large amounts of protein and other nutrients derived from a mare's diet. Total dietary protein level of the lactating mare's ration from both forage and concentrate should total 16%.

**Maintenance:** A protein requirement of 8% to 10% is needed to replace worn-out cells and provide amino acids for biological processes. Most nonworking, mature horses can meet their requirements by grazing good-quality pasture or eating good hay.

A maintenance ration will meet additional protein required to heal injuries, unless they are extensive, in which case a protein vitamin and mineral supplement should be added to the diet.—Amy Gill, Ph.D.

mares, foals, growing horses, athletic horses, and older horses; and

- Picking concentrates designed specifically for the class of horse you are feeding so you do not over- or underfeed protein. For overweight horses or those that need additional supplementation but not more calories, a protein, vitamin, and mineral mix without extra calories may be used.

Plant protein supplements are the most common source of protein in horse feeds. These are basically the high-protein parts of grains that have had the oil removed for use in other industries. Examples of plant protein supplements are:

**Soybean meal**—The most common plant protein used commercially in horse feeds is soybean meal, which provides 44% protein on an as-fed basis. The quality (biological value) of a protein supplement is based on how well the amino acids that make up the protein compliment the amino acids required by the horse to make biological proteins. The highest biological value is assigned to the proteins that have the same amino acids in relative percentages to that required by the horse.

Soybean meal is especially high in lysine, which is commonly low in most grains and must be added to equine rations. Soybean meal is a relatively inexpensive source of protein and is very palatable to horses.

Raw soybeans should never be fed to horses and always must be processed before feeding. Unprocessed soybeans contain an inhibitor of protein digestion in the horse and are especially detrimental in foal rations.

**Linseed meal**—This meal is high in sulfur-containing amino acids needed for collagen and cartilage formation. Modern processing removes most of the oil from linseed meal, making it less useful as a protein supplement than soybean meal for horse rations. Linseed meal is about 35% protein as fed, but is more expensive and has a lower biological value than soybean meal.

Linseed meal can be useful in rations of horses that suffer from tying up syndrome because it is a good source of selenium, a powerful antioxidant that works in conjunction with vitamin E to help maintain normal muscle function.

**Cottonseed meal**—Second to soybean meal in quality, cottonseed meal

contains about 39% protein on an as-fed basis. However, cottonseed meal contains a substance called gossypol that interferes with digestion and has been shown to cause problems related to infertility, slow growth, and sudden death in other species. Horses appear to be fairly resistant to gossypol toxicity, which has not been reported on a clinical basis in horses consuming gossypol at levels commonly associated with cottonseed.

However, research in other species has shown cottonseed meal to decrease sperm production, and this effect is thought to occur in stallions, too. For these reasons, cottonseed meal is rarely used in equine formulations.

### Other sources

Other protein sources for equine rations that are gaining in popularity include sunflower and canola meal, brewer's grains, distiller's grains, corn gluten feed and meal (byproducts of corn milling), and milk protein sources such as skim milk and whey. Animal protein supplements such as meat scraps or blood meal are not acceptable in most horse rations in large amounts.

Because horses are strict herbivores, the addition of animal products often results in the horse refusing to eat the feed. Animal byproducts also support the growth of bacteria that could produce toxins that cause digestive, neurological, or reproductive problems.

### Calories for metabolism and work

Carbohydrates are the main energy source in feeds. Carbohydrates are either nonstructural ("sugars"), such as those found in grains, or structural like those found in forages.

Nonstructural carbohydrates are digested and absorbed directly out of the small intestine as a single molecule of glucose. Starch from grain contains a long chain of glucose molecules linked together. All carbohydrates, from the simplest to the most complex, must be converted into glucose by the body before they can be used for energy.

In contrast to nonstructural carbohydrates, structural carbohydrates first must be metabolized by the hindgut bacteria and converted into volatile fatty acids, which the horse can use for various biological

processes and to make glucose in the liver.

Starch is the high-energy carbohydrate consumed in the largest amount by racehorses and is found in the leaves of young plants and grains. As plants mature, their starch content moves from the leaves into the seed heads where it becomes much more concentrated. Cereal grains, such as oats, wheat, barley, and corn, have about 45% to 65% starch content.

Interestingly, certain grasses will develop a seed head and can be an excellent source of high-energy starch at certain times of the year. Starch also can be a source of metabolic upset for horses that are sensitive to large amounts of it in the diet. It can lead to conditions such as insulin resistance, colic, laminitis, developmental orthopedic disease, several forms of tying up, and Cushing's disease if not well managed.

Cellulose and hemicellulose comprise the fiber or structural portion of forages. They are the main components of the leaves and stems of grasses and hay. Fibers such as beet pulp, rice bran, flax seed, and soybean hulls are being used with much more frequency in racehorse diets because they are energy-dense but safer to feed than starch.

Glucose is the primary source of energy for the racehorse, but during peak aerobic activity the muscle cells also will use fatty acids as a fuel source. Fats are a concentrated energy source for animals, providing 2½ times as much energy as carbohydrates.

Fats are expensive compared with carbohydrates, but the increased energy yield and health benefits of reducing soluble carbohydrate in the racehorse's diet are worth the extra expense. Also, horses that are adapted to a high level of fat in the diet will burn fat for energy and conserve glycogen longer than a nonfat-adapted horse. Horses that can spare glycogen during a race will be less fatigued and might have more conserved energy with which to finish.

Using fat as a fuel source creates less internal heat as opposed to the digestion and metabolism of carbohydrate-rich grains and protein. Equally as important, fat contributes energy without causing hyperactivity or excessive nervous energy produced from high-carbohydrate diets in horses that are sensitive to increases in blood sugar levels. Es-

## Carbohydrate metabolism and insulin resistance

**C**ONTEMPORARY management practices have afforded horses sedentary lifestyles while being fed excessive concentrated rations and highly nutrient-dense forages. Horses have evolved by nature to store energy and nutrients in times when feedstuffs are in abundance in order to survive when food is sparse.

Some horses, when presented with an abundance of feeds on a regular basis, quickly become obese, especially when coupled with limited physical activity. These horses become loaded with fat cells that in the past were thought to be nothing more than repositories for stored energy. Recent studies have shown these fat cells, called adipocytes, are capable of releasing a variety of hormones, or adipokines, that play a major role in regulating body mass and composition. Also, fat cells in the abdominal area possess an enzyme that converts circulating inactive cortisone into active cortisol, which directly inhibits the action of insulin, leading to or creating insulin resistance.

Insulin resistance and aberrant carbohydrate metabolism play a role in disorders such as Cushing's disease (high levels of circulating cortisol due to pituitary adenoma), peripheral Cushing's or metabolic syndrome (high levels of circulating cortisol due to intestinal enzyme that converts inactive cortisol into active cortisol), laminitis, recurrent exertional rhabdomyolysis, and polysaccharide storage

essential fatty acids in certain fats also provide the nutrients needed to produce healthy and conditioned hair, skin, and hooves.

A well-balanced diet is essential for a racehorse to perform at optimum levels. Meeting nutrient requirements is the key to a good feeding program, because deficiencies and excesses of key nutrients, such as amino acids, vitamins, minerals, soluble and structural carbohydrates and fats, will hinder growth, performance, and the general well-

being of the athletic horse. Using products that are specifically formulated for the class of horse being fed is a surest way to guarantee the horse is receiving proper nutrient levels. ☺

Many different factors are thought to contribute to developmental orthopedic disease, including genetics, nutrition, rapid growth, trauma, and excessive exercise. In addition, many growing horses exhibit insulin resistance at an early age, and the use of concentrates high in starch that elicit a high glycemic response when fed exacerbate the problem by creating a hormonal dissynchrony that affects conversion of cartilage into bone during endochondral ossification.

Insulin resistance during late pregnancy is also common in the horse and may lead to complications with delivery and affect fetal growth.

### Dietary recommendations

- Use high-fat and -fiber rations to offset the effects of blood glucose response to concentrate meals high in starch, and correct the nutritional management of the disorders.

- Feed other specific nutrients that are useful in managing the above-mentioned disorders, such as magnesium, vitamin E, zinc, and chromium. Addition of these nutrients should be done by using a balanced supplement because excess amounts can cause severe nutritional problems.—Amy Gill, Ph.D.



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