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Keeping Tabs on Carbs

Carbohydrates. Can't live with them, can't live without them.

Humans have been inundated with the supposed evils of carbohydrates. Fitness and diet aficionados warn of their capacity to widen waistlines, rendering useless all efforts to fit into that itsy-bitsy, teeny-weeny, yellow polka-dot bikini.

But what contributions—good or bad—do carbohydrates make to the equine diet? Must horsemen be mindful of counting carbs in their horses' diets? As with most topics in equine nutrition, the question cannot be answered with a simple yes or no.

The Basics

Loosely defined, a carbohydrate is a chemical compound composed of carbon, hydrogen, and oxygen. From a nutritional standpoint, carbohydrates can be divided into two types: nonstructural and structural.

Nonstructural (or soluble) carbohydrates occur as disaccharides (two simple sugars chemically bound together) or as polysaccharides (long chains of simple sugars chemically coupled). Starch constitutes the most important polysaccharide in equine nutrition. Digestive enzymes convert disaccharides and polysaccharides into usable energy sources. There is an exception to the rule of enzymes digesting disaccharides. Polymers of fructose known as fructans are bound together by bonds that can only be broken by microbial digestion in the hindgut. Dangerous fructans can make up a significant proportion of the sugars in pasture during certain phases of plant growth and under some weather conditions.

The amount of nonstructural carbohydrate consumed depends on the amount of concentrate a horse is offered. Horses on a forage-only diet, such as lightly ridden pleasure horses or barren broodmares, would ingest few nonstructural carbohydrates. Those horses that receive a considerable quantity of concentrate (textured or pelleted feed), conversely, would ingest substantially more nonstructural carbohydrates.

Structural (or insoluble) carbohydrates are resistant to the action of digestive enzymes. As such, the horse has an altogether different way of deriving energy from cellulose and hemicellulose, the two primary structural carbohydrates in the diets of horses. Bacterial fermentation in the cecum and colon breaks down these carbohydrates, thereby generating energy for the horse.

Carbohydrate Digestibility

How does a horse convert a scoop of feed or a flake of hay to energy that can fuel everyday athletic endeavors? Enzymes are key. An enzyme is any protein that brings about a specific biochemical reaction in other substances.

Monosaccharides are the only carbohydrates that can be absorbed through the intestinal wall and into the bloodstream. Therefore, all complex carbohydrates (disaccharides and polysaccharides) must be dissolved into monosaccharides before the horse can obtain energy from them. Because of specific enzymes, the separation is simple. Disaccharides such as maltose, lactose, and sucrose are split into two monosaccharide units by their respective enzymes maltase, lactase, and sucrase. These disaccharides are therefore completely digested in the small intestine of the horse.

Starch, the polysaccharide of primary importance in equine nutrition, is processed differently. The enzyme amylase, which is produced by the pancreas and pumped into the small intestine, reduces starch to its basic monosaccharide components. Amylase production in horses is limited, however. As a basis for comparison, horses produce approximately 8-10% as much amylase as an adult pig does. Because of the insufficient amylase production, starch often escapes digestion in the small intestine and heads to the voluminous large intestine, which is comprised of two key areas, the cecum and the colon.

Maximizing Starch Digestibility

Researchers have studied methods to maximize the digestibility of starch before it hits the cecum. The term "prececal digestion" is often used; this simply denotes nutrient absorption that occurs in the small intestine.

Five factors influence precedal starch digestibility in horses: source of starch, processing of starch, amount of starch intake, source and timing of forage feeding, and individual differences among horses.

Source of starch. Despite the same basic monosaccharides, not all starch molecules are identical in architecture, just as all houses are not identical notwithstanding the same raw materials: lumber, hardware, bricks, and shingles. In fact, significant differences exist among starch molecules found in the grains commonly fed to horses. For instance, oats contain the most digestible starch, while the starch in corn and barley is less digestible.

Processing of starch. Because the starch inherent in oats is extremely digestible, processing them further by rolling or crimping does little to enhance digestion. The processing of other grains, however, increases the digestibility of the starch in them.

Take corn, for instance. Kentucky Equine Research (KER) conducted a study to measure the precedal starch digestibility of corn processed in three familiar ways: steam-flaking, grinding, or cracking. Precedal starch digestibility was determined indirectly by evaluating glycemic response to each grain. As the amount of glucose in the blood rose (glycemic response), higher digestibility was assumed. Steam-flaking offered the greatest advantage in digestibility, thus reducing the likelihood of starch leaving the small intestine undigested.

Barley that undergoes heat or steam processing also makes its starch content more easily digested. As with corn, dry rolling or crushing barley does little to improve the digestibility of starch in the small intestine.

Amount of starch intake. The amount of starch consumed affects precedal starch digestibility. Researchers in California

DECODING CARBOHYDRATES

DEFINITIONS

The mechanics of carbohydrate digestion is chock-full of fifty-cent words. Here's a list of ten words that invariably crop up whenever carbohydrates are mentioned.

- **cellulose** - a complex carbohydrate present in the cell walls of plant cells
- **complex carbohydrate** - a polysaccharide
- **disaccharide** - a carbohydrate formed by two monosaccharides such as sucrose (one glucose molecule linked to one fructose molecule) or maltose (two glucose molecules joined together)
- **glucose** - a simple sugar that is a major energy source for all cellular and bodily functions; obtained through the breakdown, or metabolism, of food in the digestive system.
- **glycogen** - the primary form of carbohydrate energy stored within the muscles and the liver; it is released into the blood when needed by cells
- **hemicellulose** - a carbohydrate polysaccharide that is similar to cellulose and is found in the cell walls of many plants
- **insulin** - a hormone secreted by the pancreas that controls the amount of sugar in the blood by moving it into the cells, where it can be used by the body for energy
- **monosaccharide** - a simple sugar; a carbohydrate consisting of a single molecule such as glucose or fructose
- **polysaccharide** - a carbohydrate consisting of a long chain of monosaccharides such as starch and cellulose
- **starch** - a polysaccharide insoluble in water; the chief storage form of carbohydrates in plants

measured the pH of the large intestine after ponies were fed oat or corn starch at three different levels. The pH of the large intestine remained unfazed by oat starch regardless of the amount offered. This finding was not surprising, as the starch in oats, as previously mentioned, is extremely digestible.

For corn, however, results revealed a decrease in large intestinal pH, indicating that starch found a way past amylase-assisted digestion in the small intestine. The amount of corn starch that brought about this result was comparable to feeding an 1100-pound horse 4.5 to 6.5 pounds of corn in a single meal.

Source and timing of forage feeding. The type of forage and the time it is fed relative to cereal grains (oats, corn, and barley, for example) can have a surprising effect on prececal starch digestibility.

Nutritionists at KER studied the effect of time of hay feeding on starch utilization, once again using glycemic response as a measure of prececal starch digestibility. Six Thoroughbred geldings were fed five pounds of a typical sweet feed (a mixture of oats, corn, vitamin/mineral pellet, and molasses). The grain was fed alone, with five pounds of hay, or two hours after being fed five pounds of hay.

Starch digestion was greatest in horses that were fed only sweet feed, and a large difference was noted between this treatment and the two treatments in which grain was fed with hay or after hay.

Why the significant difference? Hay consumption stimulated salivation as well as an increase in the production of digestive secretions. To replenish fluids lost in digestive processes, horses were offered water, consuming the most two to three hours after being fed hay. Drinking diluted the intestinal contents and increased the speed at which ingesta passed through the intestinal tract. As a result, prececal starch digestibility was reduced.

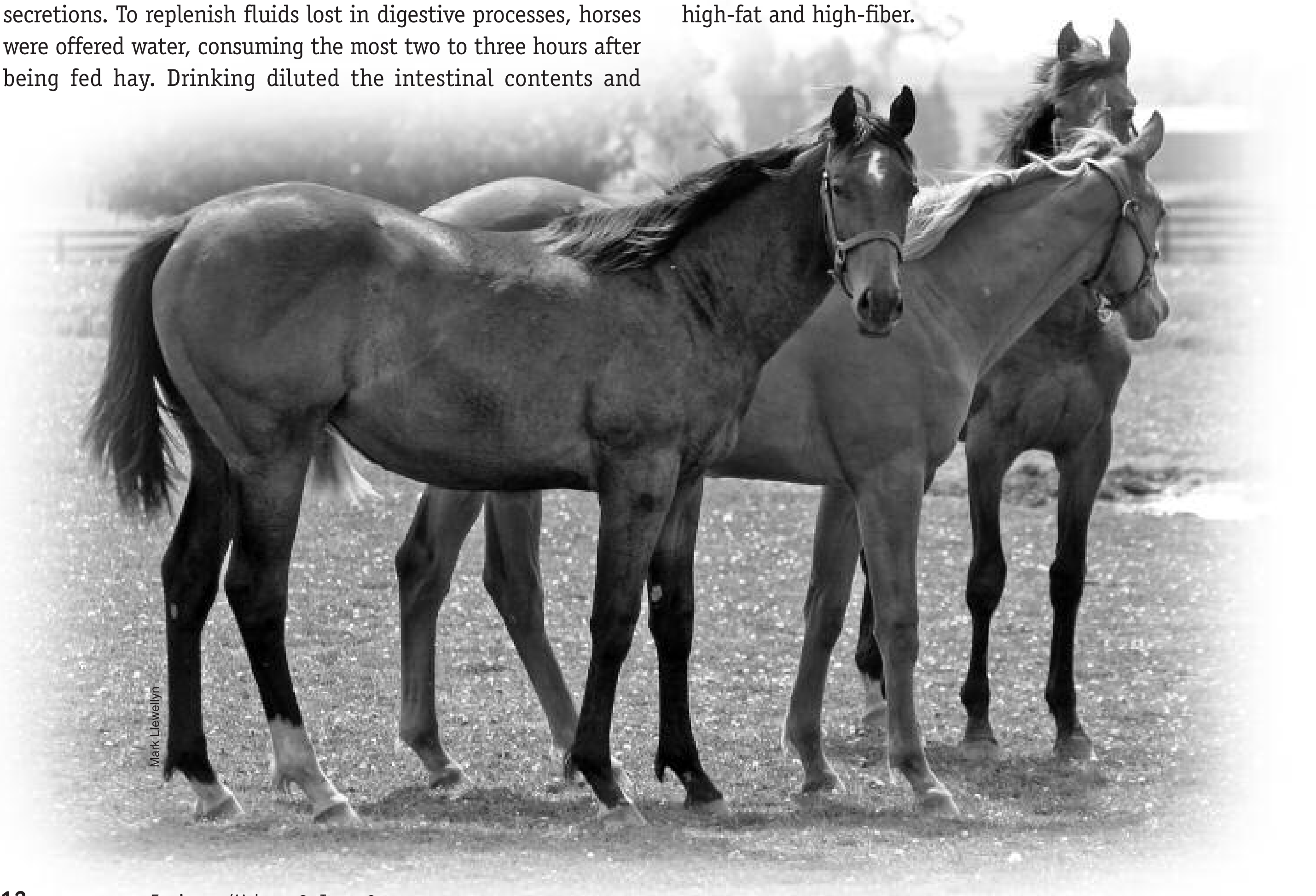
Individual differences among horses. Though scientists try tirelessly to design studies that will yield accurate, repeatable results, individual horses will sometimes foil those efforts. In real life, as in the laboratory, no two horses are alike, just as no two humans are alike. Differences in the ability to digest starch have been noted among horses and may be due to variances in rate of starch intake or passage through the gastrointestinal tract or the amount of digestive enzymes produced.

Why the Fuss over Prececal Starch Digestion?

If starch is not digested in the small intestine, it travels to the large intestine, where billions of bacteria aid in the fermentation of roughages (or the breakdown of the structural carbohydrates cellulose and hemicellulose). When starch slides undigested into the large intestine, a portion of the bacterial population feeds frenziedly on it. A product of microbial starch fermentation is lactic acid, which irritates the intestinal lining and significantly shifts the pH of the large intestine. This causes a massive die-off of other bacteria, releasing endotoxins into the bloodstream. These endotoxins are known to induce laminitis and colic.

The Answer: Search for Low-Starch Feeds

Low-starch feeds are one solution to diets too rich in complex carbohydrates. But what does low-starch mean to the horse owner? In simplest terms, low-starch can be translated into high-fat and high-fiber.



To reduce the starch content of feeds, manufacturers limit the amount of cereal grains used in the formulations. Grains must be replaced with other ingredients to confer necessary energy. Nutritionists substitute the starch in feeds with ingredients laden with fat and fiber, both of which are abundant in calories.

The most common fat sources in low-starch feeds are vegetable oil, soybean oil, and rice bran. Fat has a decided edge in the amount of dietary energy it delivers when compared to carbohydrates. Fat packs 2.25 times the calories of a similar measure of carbohydrates.

Common fiber-rich ingredients included in low-starch feeds are beet pulp and soybean hulls. Beet pulp is the residue that remains following the extraction of sugar from sugar beets, and soybean hulls are produced during the processing of whole soybeans.

What Horses Benefit?

YOUNG HORSES. Most foals are brought into this world with a specific goal in mind: they are to excel as a racehorse, a workhorse, or a show horse. An uneventful birth is only the beginning of the road for these young athletes. Each aspect of their development must be carefully planned and executed, and no aspect matters more than a sound feeding program.

Breeders have jumped on the low-starch bandwagon, and with good reason. Studies conducted at KER suggest that feeds producing a large glycemic response contribute to skeletal disorders, such as osteochondritis dissecans (OCD), in young horses.

OCD is characterized by a disruption in the maturation of cartilage, the connective tissue that affords joints much of their resilient, concussion-absorbing properties. Researchers at KER theorize that spikes in insulin, which occur when weanlings and yearlings consume starch-riddled diets, may play a role in the development of OCD.

To assess the relationship between glycemic response and the incidence of OCD, KER conducted a study that used 218 Thoroughbred weanlings on several central Kentucky farms.

Each weanling was offered a specific amount of carbohydrate in the form of a grain meal. Two hours after the grain meal, a blood sample was taken and levels of glucose and insulin were measured. Diagnosis of OCD was also recorded from the time the study commenced until horses were sold as yearlings at 16 to 20 months of age. A diagnosis of OCD was only given to young horses that required surgical treatment of lesions in the fetlock, hock, shoulder, or stifle.

What did this study reveal? Researchers found an increased incidence of operable OCD lesions in young horses fed concentrates with a high glycemic index.

The key to staving off OCD lesions in genetically predisposed weanlings and yearlings might be the use of low-starch feeds, which will decrease the glycemic response and theoretically reduce the likelihood of skeletal problems.

So, what does a conscientious breeder look for in a feed for young horses? Feeds should contain 6-10% fat but no more, as nutritionists at Virginia Polytechnic Institute and State University found that feeding a concentrate with more than 10-15% may hinder calcium metabolism in young horses. The feed should also contain at least 12% fiber.

Breeders should look for high-fat, high-fiber feeds specifically geared for growth, as these will be properly fortified with the minerals and vitamins necessary for skeletal development.

The window for development of OCD lesions is narrow, considering horses continue growing, albeit at a slower pace, through their fourth, fifth, or sixth birthdays.

MATURE HORSES. When the glucose-insulin apparatus works unfailingly, the horse is able to properly store glycogen for energy. In some instances, however, the insulin receptors that remove glucose from the blood become stoic, less sensitive to the effects of glucose. This causes glucose to remain in the blood, and because glucose levels are elevated, the pancreas continues to produce insulin. This often leads to a buildup of insulin in the bloodstream and a condition called hyperinsulinemia.

The primary danger of hyperinsulinemia stems from the inability of the body to use glucose as an energy source. Without the energy from glucose, the horse must use its fat and muscle stores to fuel body functions. A loss of weight and muscle mass is almost unavoidable in horses with untreated hyperinsulinemia. If the condition continues unchecked, the body may quit producing insulin altogether.

Few adult horses are troubled by the nuisance that is hyperinsulinemia, so low-starch feeds are not necessary for the majority of horses.

However, there are a few exceptions. Low-starch diets are indicated for certain disorders:

Cushing's syndrome. Horses suffering from Cushing's syndrome, an endocrine disorder common among aged horses, often have hyperinsulinemia. Researchers have reason to believe that this hyperinsulinemia is a result of insulin resistance. Lowering the starch consumed by the horse will help alleviate hyperinsulinemia.

PSSM and RER. Polysaccharide storage myopathy (PSSM) and recurrent exertional rhabdomyolysis (RER) are two forms of tying-up that seem to be exacerbated by high-starch diets. In fact, horses were more likely to experience tying-up when being fed high-starch diets. When switched to low-starch rations, most horses are completely relieved of muscle problems.

Some researchers believe reduction in the number of tying-up episodes due to RER may be linked to changes in behavior. As starch levels in the diet are minimized, excitability subsides. Excitability is thought to provoke RER-related tying-up.

Laminitis. Insulin-resistant horses are more prone to laminitis, though scientists and veterinarians cannot pinpoint a reason for the phenomenon. It is, however, well known that a horse that has suffered one bout of laminitis is more susceptible to successive ones. Therefore, a low-starch diet is prudent for laminitic horses.

Low-starch feeds are not designed as a cure for the aforementioned conditions. As an adjunct to veterinary supervision, they are a reasonable starting place in the management of these problems.