Carbohydrates in Equine Nutrition

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The term "low carb" has become very popular today when talking about human nutrition. The Atkins and South Beach diets have focused attention on low carbohydrate diets for people, and many horse owners are concerned and confused about carbohydrates in equine nutrition. Recent research is starting to address the area of carbohydrates in equine nutrition. When determining low carbohydrate diets for horses, we need to look at sugar and starch levels in equine feeds. These feedstuffs include forages (hay and pasture), as well as ingredients that make up concentrate feeds for horses, such as oats, corn, barley, beet pulp, soybean meal, etc.

Nonstructural carbohydrates (NSC) are the sugars and starches found inside the plant cells of equine feedstuffs. This is in contrast to the structural carbohydrates that compose the cell wall of the plants that horses eat. The two main cell wall components are cellulose and hemicellulose, also known as fiber. Plant fiber is digested due to the work of bacteria and protozoa in the large intestine or hindgut of the horse. The horse receives some of its energy supply by absorbing organic acids in the large intestine. The bacteria and protozoa in the hindgut produce these organic acids from fermentation of sugars that are released when fiber is broken down by enzymes secreted by these same bacteria and protozoa. NSC equals sugars and starches that were thought to be completely digested in the small intestine of the horse, however, another group of sugars, called fructans, has been found that complicates our understanding of carbohydrate digestion and further explanation is needed.

Sugars found in forages include glucose, fructose, sucrose and fructans. Starch, which consists of chains of glucose and fructose molecules, is the major carbohydrate stored in legumes like alfalfa, warm-season grasses such as coastal bermudagrass and cereal grains (corn and oats). Fructans are water-soluble sugars (chains of fructose molecules) that are stored as the major carbohydrate in cool-season grasses such as orchardgrass, fescue and timothy.

Starch and sucrose can be broken down into glucose and fructose molecules in the horse's small intestine and absorbed because there are enzymes capable of breaking these types of molecular bonds. Fructans are not digested into fructose and absorbed in the small intestine of the horse, as there are not enzymes present to break these types of bonds. However, bacteria and protozoa in the horse's large intestine can ferment fructans into lactic acid.

Research has shown that excessive consumption of fructans from pasture grasses or excessive intake of sugar and starch from feeding too much grain will cause colic and laminitis. If large amounts of sugar, starch or fructans are consumed, they can pass through the stomach and small intestine of the horse in an undigested state. Fructans cannot be digested in the small intestine, and feeding too much starch and sugar at one meal will

overwhelm the horse's upper digestive system (stomach and small intestine) due to the rapid passage rate of concentrate feeds. When large amounts of sugar, starch or fructans are present in the hindgut, they are rapidly fermented. Excessive fermentation in the hindgut results in large amounts of lactic acid that can lower the pH to the point at which most of the bacteria are destroyed. These bacteria then break apart and release toxins that are absorbed into the bloodstream. These toxins are believed to cause laminitis in the horse. Carbohydrate values for equine feedstuffs have been determined by two different methods. Nonfibrous carbohydrate (NFC) values are determined by the use of an equation that calculates plant cell components by subtracting analyzed components (crude protein, crude fat, neutral detergent fiber and ash) from the total sample weight. It is not the preferred method of reporting soluble plant components because this fraction contains other components than sugar, starch and fructans. The preferred analytical method is an enzymatic digestion process that tests specifically for sugar and starch, with the process for sugar analysis also including fructans. Laboratories that use this procedure include Equi-Analytical Laboratories in Ithaca, NY and Rumen Fermentation Profile Lab at West Virginia University. A new enzymatic testing method that can separate sugar, starch and fructan fractions of forages has been developed, but there are no commercial laboratories that are available to the public at this time.

The greatest danger of founder and laminitis for horses are consumption of cool-season grass pasture and hay, which may contain high levels of sugar, especially large amounts of fructans. Legumes, warm-season grasses and grains contain little to no fructans. Good management of pasture for grazing and hay production including maintaining proper fertility levels and prevention of overgrazing and weed establishment will keep the sugar content of the forage at a lower and safer level. Pasture and hay made from small grains (wheat, rye, barley, and oat) and perennial ryegrass, fescue and bromegrass under certain environmental conditions can have extremely high sugar levels.

Tying up disease or exertional rhabdomyolysis can exist in horses as sporadic and chronic forms. Sporadic forms can affect any breed and can be the result of overwork, inadequate conditioning and muscle fatigue, or nutritional deficiency (potassium, vitamin E, selenium, etc.). The genetic forms of ER have been divided into equine polysaccharide storage myopathy (EPSM), polysaccharide storage myopathy (PSSM), and exertional rhabdomyolysis (ER). The incidence and severity of both forms of ER can be lowered with a reduction in the dietary NSC. Dietary recommendations for horses with all types of ER includes increasing dietary fat to contribute 15 to 20% of the horse's daily energy requirement and reducing dietary NSC levels to below 20%. For example, a horse diet containing ten pounds of 10% fat feed and fifteen pounds of hay would contain approximately 5% total dietary fat, and this amount of fat would provide 11.25% of total daily calories. Large amounts of dietary fat would be appropriate for performance horses, but not for horses with lower activity levels, especially horses that are overweight or "easy keepers". This same recommendation of controlling dietary NSC to below 20% of the total diet can be applied to the feeding management for other problem horses afflicted with Cushing's Disease, insulin resistance, equine diabetes and osteochondrosis dissecans (OCD) problems in young, growing horses with a genetic sensitivity to high carbohydrate diets.

Table 1 shows sugar, starch and NSC values for selected feedstuffs typically provided to horses. The lowest NSC values are for soybean hulls, beet pulp, alfalfa and the feedstuffs with highest NSC values are corn, barley and oats. It is obvious that grain-based horse feeds will contain significantly higher NSC values than feeds based on beet pulp, soybean hulls and alfalfa meal. For more information about NSC content of forages go to www.equi-analytical.com.

Sugar, starch and NSC values for all Southern States horse feeds are listed in Table 2. Several feeds that are beet pulp based have the lowest NSC values, including Triple Crown Complete, Senior and Growth. Also, there are two horse feeds based on soybean hulls, Triple Crown Lite and Low Starch, that have the lowest NSC levels of any Southern States feeds. Triple Crown Lite is recommended for ponies, miniature horses, overweight horses and "easy keepers". Triple Crown Low Starch is the latest horse feed in the Southern States line. Triple Crown Low Starch, with 15% total NSC, has been developed to provide a low dietary NSC feeding program for problematic horses with ER, Cushing's Disease, laminitis, insulin resistance and diabetes.

A low NSC feeding program for problem horses would start with estimating the NSC content of your pasture or hay or having an actual sample analyzed for NSC content. Sampling your hay would not be practical unless you had a uniform supply from the same cutting and field that would last you for several months. If pasture is available for a horse with these types of problems, the most prudent feeding management to reduce NSC levels in the diet would be to eliminate or reduce grazing. Moving the horse to a barren lot for activity only or the use of a grazing muzzle to lower or eliminate pasture consumption can accomplish this. Then provide hay that is selected for a low NSC content. One surprising finding concerning NSC levels of various hays was that alfalfa hay and alfalfa cubes had lower values than grass hay, so alfalfa hay may become the first choice for problematic horses due to lower NSC content and the absence of fructans.

The next step is to select a horse feed with a low NSC level and an appropriate fat level. For a problem horse with little activity or that is an "easy keeper", Triple Crown Lite with only 3% fat would be suitable. For a problem performance horse, a horse in poor body condition, or "hard keeper", feeds such as Triple Crown Complete and Triple Crown Senior, both with 10% fat, or Triple Crown Low Starch (6% fat) would be a better choice.

Table 3 contains feeding examples for problem horses using Triple Crown Complete, Lite, Senior and Low Starch to provide dietary NSC levels below 20%. Providing carbohydrate values for Southern States horse feeds will enable horse owners and veterinarians to better treat problem horses, and the continuing nutrition research that Southern States is conducting will allow safer horse feeds in the future.

Table 1. Average Sugar, Starch and Non-Structural Carbohydrate (NSC) Values of Selected Feedstuffs*.

Feedstuff	Sugar	Starch	NSC
Oat Hay	16.0%	6.3%	22.1%
Barley Hay	14.9%	5.8%	20.4%
Alfalfa Hay	8.9%	2.5%	11.3%
Bermudagrass Hay	7.5%	6.1%	13.6%
Grass Hay	11.1%	2.9%	13.8%
Alfalfa Pellets	7.2%	2.3%	9.3%
Alfalfa Cubes	8.3%	2.0%	10.2%
Grass Pasture	10.3%	3.4%	12.1%
Rice Bran	6.2%	17.7%	21.2%
Oats	4.8%	44.4%	54.1%
Corn	3.7%	70.3%	73.3%
Barley	6.0%	53.7%	61.7%
Beet Pulp	10.7%	1.4%	12.3%
Wheat Bran	8.3%	22.8%	31.1%
Soybean Hulls	4.3%	1.9%	6.3%
Wheat Middlings	10.1%	26.2%	32.0%
Soybean Meal	14.3%	2.1%	16.2%

*Values are from Equi-Analytical Laboratories, Ithaca, NY, reported on dry matter basis.

Table 2. Sugar, Starch and Non-Structural Carbohydrate (NSC) Values*.

Horse Feed and Form	WSC	ESC	Starch	Starch + ESC	NSC
Triple Crown 14% Performance *Textured*	6.3%	5.6%	31.8%	37.4%	38.1%
Triple Crown Complete *Textured*	8.8%	8.8%	11.8%	20.6%	20.6%
Triple Crown Senior *Textured*	5.3%	5.3%	6.4%	11.7%	11.7%
Triple Crown Growth *Textured*	8.3%	7.8%	5.6%	13.4%	13.9%
Triple Crown Low Starch *Pelleted*	3.1%	3.1%	10.4%	13.5%	13.5%
Triple Crown TLC *Pelleted*	8.4%	5.0%	8.3%	13.3%	16.7%
Triple Crown Lite *Pelleted*	4.8%	4.8%	4.5%	9.3%	9.3%
Triple Crown 30% Supplement *Pelleted*	8.0%	8.0%	1.8%	9.8%	9.8%
Triple Crown Safe Starch Forage *Chopped*	7.2%	4.3%	1.8%	6.1%	9.0%
Triple Crown Grass Forage *Chopped*	9.7%	8.1%	4.5%	12.6%	14.2%
Triple Crown Alfalfa Forage *Chopped*	9.9%	8.0%	4.7%	12.7%	14.6%

*Values determined by Equi-Analytical Laboratories, Ithaca, NY, reported on as sampled or as fed basis. WSC is water soluble carbohydrates, ESC is ethanol soluble carbohydrates, NSC is nonstructural carbohydrates and NSC = Starch + WSC. Select horse feeds and forage with low Starch + ESC values for horses to prevent laminitis, tying up disease (EPSM, PSSM, RER), prevention of Developmental Orthopedic Disease (DOD), calmer behavior and reduced insulin resistance for Equine Metabolic Syndrome and Equine Cushing's Disease. Also, forages with high NSC values (fructans) are more likely to cause laminitis. All Triple Crown Feeds have fixed ingredient formulas, values reflect an average analysis of multiple feed samples.

Table 3. Problem Horse Feeding Programs with Triple Crown Horse Feeds for Dietary Nonstructural Carbohydrate (NSC) Levels Below 20%.

Example 1: 1,100-pound horse in moderate work with tying up disease fed 15 pounds daily of grass hay (15% NSC) and 8.5 pounds daily of Triple Crown Low Starch (13.5% NSC) has a total dietary NSC level of 14.5%.

Example 2: Obese 1,000 pound horse with insulin resistance at maintenance fed 12 pounds daily of grass hay (15% NSC) and 2 pounds daily of Triple Crown Lite (9.3% NSC) has a total dietary NSC level of 14.2%.

Example 3: 1,100-pound horse with tying up disease at moderate work fed 15 pounds daily of alfalfa hay (12% NSC) and 9 pounds daily of Triple Crown Complete (20.6% NSC) has a total dietary NSC level of 13.4%.

Example 4: 1,400-pound horse with tying up disease in moderate work fed 15 pounds of grass hay (15% NSC) and 12 pounds daily of Triple Crown Complete (20.6% NSC) has a total dietary NSC level of 17.5%.

Example 5: 1,200-pound barrel horse with chronic laminitis at moderate work fed 15 pounds daily of alfalfa hay (12% NSC) and 8.5 pounds daily of Triple Crown Complete (20.6%) has a total dietary NSC level of 15.1%.

Example 6: 1,200-pound older horse with Cushing's Disease at maintenance fed 10 pounds of Triple Crown Senior (11.7%) daily and 6 pounds per day of alfalfa hay (12% NSC) has a total dietary NSC level of 11.8%.

Example 7: 800-pound pony with recurrent laminitis at moderate work fed 12 pounds of Triple Crown Chopped Alfalfa Forage (12.7% NSC) daily and 6 pounds of Triple Crown Low Starch (13.5% NSC) has a total dietary NSC level of 12.8%.

Example 8: 500-pound weanling (6 months old) gaining 1.5 pounds per day (1100 pound mature weight) with mare's foals having history of OCD problems fed 7.5 pounds of alfalfa hay (11% NSC) and 6 pounds of Triple Crown Growth (13.9% NSC) daily has a total dietary NSC level of 12.3%.