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Changing Carbohydrate Evaluations in Animal Diets

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Nutritionists are doing away with "non-structural carbohydrates" in favor of more specific measures

If you own a horse with laminitis or a metabolic problem such as insulin resistance or Cushing's disease, chances are you've heard recommendations to minimize his intake of non-structural carbohydrates (NSC). However, many nutritionists and feed analysts are now saying that NSC isn't the best measure to evaluate when you're counting a horse's carbs.

One major reason is significant variation in the way different laboratories measure NSC components and calculate its value. Interpreting research and making dietary recommendations are impossible when feeds are not analyzed consistently.

"I do not use NSC anymore because it has different meanings to different people," comments Laurie Lawrence, PhD, professor of equine nutrition at the University of Kentucky and chair of the committee that recently revised the National Research Council's publication *Nutrient Requirements of Horses*.

The other reason--probably the biggest one for horse owners--is the fact that NSC doesn't give you a complete picture of the types of carbohydrates in a feed or forage that can affect your horse's condition (more on this shortly).

"We need to do a better job of understanding carbohydrate components and balancing rations based on them, because all carbs are not created equal," states Paul Sirois, manager of Dairy One/Equi-analytical Forage Analysis Laboratories in Ithaca, N.Y., and one of the leaders of the movement away from NSC. "NSC was a good place to start, but we can do better now."

Following extensive collaboration between feed analysts, nutritionists for multiple species, nutrition researchers, and feed industry regulators, the NSC value will be progressively dropped from many laboratory analyses, research methodologies, and feeding guidelines across multiple animal species. In fact, Dairy One/Equi-analytical has already dropped NSC from its reports, effective April 1.

What NSC Doesn't Tell You

The group of carbohydrates lumped under the NSC label includes nearly all the non-fiber carbohydrates—those that come from plant cell contents rather than tough, fibrous cell walls. They are generally more easily digestible and yield more energy to the horse than the fiber carbohydrates, but they're not all digested in the same part of the horse's gastrointestinal tract or by the same process. Thus, they affect a horse's blood sugar and

gastrointestinal health differently, and this is why it's important that they be evaluated separately.

Sirois explains: "Let's say one hay sample has 5% simple sugars+starch and 10% fructan, with an NSC value of 15%. And you have another with 10% simple sugars+starch and 5% fructan that is also 15% NSC. They're not the same hay even though they have the same NSC value. The one that's 10% simple sugars+starch might be more of a problem for the insulin-resistant horse (because simple sugars and starch, which are primarily digested in the small intestine, cause a greater glycemic or blood sugar response than fructans). The hay that's 10% fructan could be more of a problem for a laminitic horse." (Fructans are primarily digested in the large intestine; large doses can upset the microbial population there, resulting in colic and/or laminitis. Some fructans are in fact used at high doses to induce laminitis in some research situations.)

"If you're evaluating a horse's ration based only on NSC, you're not getting the whole picture," he summarizes.

So What Do We Use?

Instead of looking at NSC, nutritionists are recommending that we evaluate water-soluble carbohydrates, ethanol-soluble carbohydrates, and starch. None of these measures are new, and each describes carbohydrates that affect the horse differently based on how they're digested.

Water-soluble carbohydrates (WSC)—These include carbohydrates that are extracted from a sample by dissolving them in water. Simple sugars and fructans make up this measure, which is simply termed "sugar" on some analyses. Interpreting and using this value depends on the proportions of sugars and fructans in the sample; simple sugars are digested and absorbed in the small intestine and have a significant impact on blood sugar (glycemic response), while fructans are fermented in the large intestine and induce a much smaller response. However, when eaten in large amounts, some fructans have been shown to cause laminitis due to disruption of the bacterial population in the large intestine. Fructans are rarely analyzed separately from other WSC.

Ethanol-soluble carbohydrates (ESC)—These carbohydrates are soluble in 80% ethanol; they are a subset of WSC that is primarily digestible in the small intestine and includes much fewer fructans. As such, this fraction is generally used to evaluate one set of carbohydrates in a feed that will induce a high glycemic response. Depending upon the lab doing the analysis, WSC and ESC may both be reported as "sugar." This has caused a lot of the confusion in the industry, notes Sirois. "At Dairy One/Equi-analytical, we no longer report 'sugar,' " he adds. "Carbs are correctly identified as either WSC or ESC."

Starch—Made up of many glucose molecules, the starches are mostly broken down to single glucose molecules. Thus, they also induce a high glycemic response. Historically, NSC values have been calculated by adding starch to either WSC or ESC.

Interpreting the "New" Numbers

Lawrence provides guidance on using WSC, ESC, and starch values to plan equine diets: "If the values for starch and ESC are low, there will be little glucose available to be absorbed

from the small intestine." This would mean a low glycemic response, which is good for insulin-resistant horses or others that can't handle large swings in blood sugar levels.

"If the WSC and starch values are low, there should be only a small amount of material reaching the large intestine that will be rapidly fermented," she adds. "Thus low starch + low WSC should mean less opportunity for large intestinal disturbances." This feed would be good for a laminitic horse, particularly one whose disease was initiated by diet-related colic.

But what numbers are "low" for these carb values and what numbers are "high?"

"Lots of people have opinions on that, but there is a lack of good data to support a specific number," says Lawrence. Hopefully, standardizing the way researchers and nutritionists evaluate carbs will provide us with research we all know how to interpret, so we can get these numbers in the future. An equine nutritionist can help you sort through the carbohydrate types to plan a diet with carbohydrate levels that are most suitable for your horse.

"Carbohydrate analysis is complicated because there are so many different compounds produced by plants," she comments. "Most of us think of starch and cellulose as the main carbohydrates in plants, which they are in many feed ingredients. But as we use new and different ingredients and we look closely at the plant in different growth stages, it becomes clear that there are many, many other carbohydrates that we need to be aware of."

The recently released revision of the *Nutrient Requirements of Horses* discusses metabolism and analysis of the various carbohydrate types and measures, including NSC, but does not recommend using NSC to evaluate whether a feed is suitable for a horse's diet.

"The publication recognizes that diets low in starch and sugars are helpful in managing horses with certain disorders, such as polysaccharide storage myopathy, and that high levels of dietary starch may affect gastrointestinal function, but it does not include carbohydrate recommendations for most categories of horses," notes Lawrence. Consistent analysis methods should help researchers develop these recommendations in the future.

Regulatory Implications Minimal

You won't see any updated regulations or laws on animal feed carbohydrates for some time, but the industry is working on it. Richard Ten Eyck is the Oregon Department of Agriculture Feed Specialist and chair of the Carbohydrate Working Group of the Feed Labeling Committee for the Association of Animal Feed Control Officials (AAFCO). He says that while his group intends to present carbohydrate fraction terminology and labeling guidelines for discussion at the organization's August meeting, he doesn't expect them to appear in the AAFCO Official Publication until at least 2009.

"After that, it would take a period of time for the industry and states to adopt them (if they even choose to; AAFCO develops advisory guidelines but has no regulatory authority)," he notes. "It's years away from anything possibly becoming law." Removing NSC from AAFCO publications isn't an issue; he says that carbohydrate estimation never was included in the guidelines.

There are already feeds/forage products being marketed as "low-carb" or "low-NSC." Some of them are in Ten Eyck's state of Oregon, which is one of very few states with any

carbohydrate guidelines for feed labels (these are based on NSC content and can be seen at www.oregon.gov/ODA/AHID/commercial_feed/low_nsc605.pdf). One might wonder: How will this shift in carbohydrate evaluation affect labeling and marketing of those feeds?

"On a national level, you won't see a definition of what low-carb or low-sugar feed is," he commented. "Low compared to what? In Oregon, we picked a number for our guidelines, but you probably won't see anything like that nationally (at least not without more research). We will probably let our guideline stand until the AAFCO revision comes out."

But he notes that feed companies can already include on labels values for NSC, WSC, ESC, or anything else they can measure and guarantee.

Take-Home Message

It's been proposed that carbohydrates be classified based on their digestion method and nutritional effects on animals rather than by analytical method (i.e., ethanol or water extraction), as they are now. Unfortunately, analytical methods are not yet available to give us this information, so we must continue to classify carbohydrate groups based on the methods we can currently use to analyze them. We just need to pick the right carb measures so we can choose feeds based on their effects on the horse.

"Moving away from NSC is a step in the right direction," Sirois comments. "A lot of people sample multiple hays just for that, to see which one has the lowest value, then do a full nutrient analysis on their selection. (NSC) was a good place to start, but we need to move away from that mindset and replace it with the evaluation of more specific carbohydrate types."

Carbohydrate Analysis Overview

If it seems like you need a graduate degree to make sense of the many types of carbohydrates, don't worry—we've put together a guide to the carbohydrate types you're most likely to see on a feed/forage analysis report. We'll give you the carbohydrate name, description, and nutritional significance for horses:

NDF (neutral detergent fiber) Total plant cell wall carbohydrates, including ADF (see below) and hemicellulose; often considered an indicator of forage quality and intake potential (lower NDF=less hard-to-digest fiber=higher "quality," higher intake).

ADF (acid detergent fiber) Less digestible carbohydrates in plant cell walls, including cellulose and lignin ; higher ADF=lower digestibility.

NFC (non-fiber carbohydrates) A calculated estimate of carbohydrates composed of starch, simple sugars, fructan, soluble fiber, and fermentation acids; calculation may vary, but generally equals 100% minus (CP+NDF+Fat+Ash). A rough estimate of carbohydrate value (high NFC generally indicates more digestible carbohydrates than indigestible fiber types).

NSC (non-structural carbohydrates) Intended to describe easily digestible carbohydrate components of a feed more specifically than those in NFC; usually calculated as WSC+starch or ESC+starch. Questionable because of varying analysis methods and results.

WSC (water-soluble carbohydrates) Carbohydrates solubilized and extracted with water, including simple sugars and fructans (see below); sometimes called "sugar" on analysis reports. Interpretation of WSC is dependent upon the relative proportions of simple sugars and fructan as they are metabolized at different sites in the gastrointestinal tract. High WSC might indicate high fructan levels in grasses or high simple sugars in nongrass forages and grains.

Fructans Carbohydrate compound made up of many fructose molecules (complex sugar); fermented and digested primarily in the large intestine. Occasionally analyzed separately from WSC. Present in primarily grass forages; one type is used at high doses in many laboratories to induce laminitis.

ESC (ethanol-soluble carbohydrates) Carbohydrates that dissolve in 80% ethanol solution; these carbohydrates are a subset of WSC that are primarily digested in the small intestine and give a true glycemic (blood sugar) response. However, some fructans can be included in this fraction. High ESC generally means a feed will generate a high glycemic response (unless there is a high level of fructans in this fraction). Might be helpful for hard-working horses that need lots of energy, not so good for horses that are sensitive to large blood sugar changes (i.e., insulin-resistant horses). However, low ESC does not necessarily mean the feed will have a low glycemic response, because starch could keep it high.

Starch A polysaccharide composed of many linked glucose molecules found mainly in grains; mostly digested in the small intestine, where they are broken down and absorbed as glucose (simple sugar). Some starches are resistant to small intestine digestion and are fermented in the large intestine; a typical analysis does not differentiate between the two types. Low starch content generally means little glucose will be absorbed in the small intestine (low glycemic response). This is good for horses that can't handle large blood sugar changes (i.e., insulin-resistant horses). High starch generally means a high glycemic response.

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