Carbohydrates in New NASEM Requirements of Dairy Cattle

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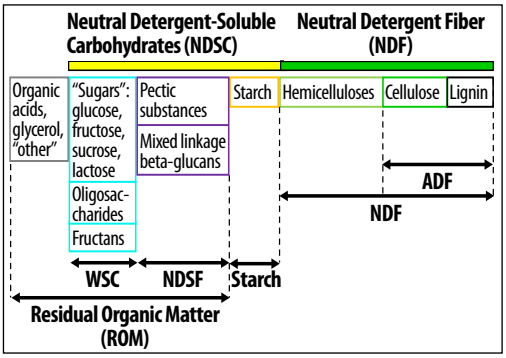
Carbohydrates from forages are key players in dairy cattle diets, providing nutrition and chewable fiber that keep cows healthy and productive. The 2021 Nutrient Requirements of Dairy Cattle (NRC), 8th edition from the National Academies of Sciences, Engineering, and Medicine (NASEM 2021) keeps much of the familiar landscape of carbohydrates we've been using, but provides some new additions, revisions, and applications (Figure 1).

Figure 1. Carbohydrate fractions in feeds. ADF = acid detergent fiber, NDSF = neutral detergent-soluble fiber, WSC = water-soluble carbohydrates.



Neutral detergent-soluble carbohydrates (NDSC) include the more readily fermentable carbohydrates: water-soluble carbohydrates (WSC), starch, and neutral detergent-soluble fiber (NDSF). The WSC include sugars, fructans from cool season grasses, and oligosaccharides (short chains of sugars). Soluble fiber is a kind of fiber not in NDF. It includes pectins and other polysaccharides not digestible by mammalian enzymes. Legume forages (alfalfa, clovers) are good sources of soluble fiber. Starch consists of chains of glucose that can be digested by microbes or the animal. Corn and other grain-crop silages are forage sources of starch. Neither WSC nor soluble fiber are used to calculate nutrient supply in NASEM 2021 because there was not enough published research to define their specific impact. Of the NDSC, starch receives the most focus. Not surprising, since most NDSC research has centered on starch. Why? Besides accounting for a substantial portion of many dairy cattle diets, we have good, relatively easy methods to measure starch in feeds, diets, and feces to assess its digestibility, something we lack for soluble fiber and WSC.

The 2001 NRC relied on nonfiber carbohydrates (NFC) calculated by-difference to describe readily available carbohydrates. NASEM 2021 omitted NFC, made starch its own fraction, and came up with a new by-difference fraction: residual organic matter (ROM). ROM covers carbohydrates not accounted for by starch and NDF. It is calculated as: total organic matter – crude protein (CP) – starch – NDF – fatty acids. ROM contains WSC, soluble fiber, fermentation acids like those in silage, glycerol, and other feed components not measured in the main nutrient fractions. Similar to NFC, ROM is estimated to be 96% truly digestible. Before you get bothered that a variety of fractions we can measure were combined into ROM, remember two things: 1) using ROM and starch reduces the size of the "nutritional black box" that NFC was, and 2) the NASEM committee didn't find enough published data to describe the impact of ROM carbohydrates. The only way to find whether parsing NDSC further will improve how well we predict nutrient supply and cow performance is to do the research.

On feed analyses, you may see "NDF" and "NDFom." The "om" stands for "organic matter" or "ash-free," meaning the ash in NDF was subtracted out. The NASEM 2021 nutritional model uses NDF values that include ash because that was the version of NDF used in research studies to develop the recommendations. Typically, ash is a minor part of NDF. However, if a forage sample NDF shows heavy ash/soil contamination, resampled feed should be analyzed or NDFom should be used to avoid counting the excess ash as carbohydrate.

Microbial protein production, an important source of protein to the cow, is calculated from predictions of how much starch and NDF are fermented in the rumen in NASEM 2021. A number of factors affect these predictions. While the amount of fermented starch and NDF are affected by dry matter (DM) intake, NDF fermented is also affected by dietary concentrations of CP, wet forage, and ADF/NDF. Starch is influenced by dietary concentrations of forage NDF, wet forage, and starch (yes, starch). The forage NDF likely affects passage and how long feeds stay in the rumen to be fermented. Crude protein may relate to meeting the needs of the fiber digesters, while starch concentration may relate to maintaining a population of microbes that ferment starch.

Physical form and NDF are crucial to maintaining proper rumen function and health. The NDF in forages is particularly important. Its typically larger particle size encourages rumination, and the slower fermentation and breakdown of NDF maintains its form and makes it available to be chewed for a longer time. As a starting

point for maintaining good rumen function, NASEM 2021 has a table for recommended dietary minimum total NDF and forage NDF and maximum starch concentrations. Forage NDF should be increased to balance as starch increases and total NDF decreases. But factors affecting a cow's fiber needs are more complex. A NASEM 2021 figure gives guidelines for adjusting dietary forage NDF depending on diet and management factors (Table 1). Another approach in NASEM 2021 is physically adjusted NDF (paNDF) which works with the interaction of forage NDF, starch, particle size measured on the Penn State Particle Separator (PSPS), and other elements in the diet affecting ruminal pH. It gives recommendations for the proportion of the diet DM that should be on the PSPS 8 mm/0.315" sieve. Recommended analyses for measuring carbohydrates are listed in the Feed Analysis chapter of NASEM 2021.

Table 1. Based on NASEM 2021 Figure 5-2.

Suggested direction for adjusting for optimal forage NDF
17% <------- Forage NDF% of diet DM -------> 27%
<--Higher – DM intake
<--Added buffers in diet
Forage chop length – Finer-->
Starch % of diet – Higher-->
Starch degradability – Higher-->
Bunk space – Limited-->
Slug feeding – Yes-->
Daily variation in diet and mixing – High-->