# New Concepts in Sugars and Starches for Dairy Cattle

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We continue to learn about factors that affect how diets function in dairy cattle. In the case of nonfiber carbohydrates such as starch and the water-soluble carbohydrates, we are also finding out what other factors outside of these carbohydrates affect their use. A few specific items that go beyond the basics:

- The more starch that's fed, the more rapidly it ferments, with the rate of starch in high moisture corn increasing more than with dry ground corn. At the same time, the measured yield of microbial nitrogen from organic matter truly fermented in the rumen was greater for the more slowly fermenting dry ground corn (Oba and Allen, 2003). This may have to do with how microbes handle rapidly available carbohydrates (see note on glycogen).
- Ruminally degradable protein, but not high moisture corn or dry ground corn, increased lactic acid detected in the rumen (Hall, 2013).

Water-soluble carbohydrates (WSC) are typically what we are talking about when we talk about "sugars".  The WSC include monosaccharides such as glucose and fructose (yes, these are real sugars), disaccharides like sucrose and lactose (real sugars, too), as well as galacto-oligosaccharides such as stachyose and raffinose (not sugars), fructans (in cool season grasses, not sugars), and any other carbohydrates soluble in water. With the exception of lactose (milk sugar) which ferments more slowly, all of the WSC appear to be rapidly available to the rumen microbes.  Key things to know about WSC use by microbes:

- If there is more WSC than RDP available, or the WSC is very rapidly available, microbes may store the WSC internally as glycogen, a carbohydrate much like starch. Overfeeding RDP is not a good solution to this. Production of glycogen slows down rumen fermentation and may help to maintain a higher rumen pH.
- Glycogen production requires energy – 1 ATP per glucose added to the chain (Stouthamer, 1973).  This will reduce the amount of energy available to make microbes.
- In vitro, providing peptides (RDP) vs. urea gave a much higher yield of microbial nitrogen, and reduced production of glycogen (Hall, 2017).
- The more rapidly a WSC ferments, the more microbial protein is produced, even with substantial glycogen production (a dilution of maintenance?).

Among the WSC as compared to starch, feeding sugars tends to increase or maintain milk fat production.  We are not sure exactly why this occurs, but it may be due to increased biohydrogenation of fatty acids in the rumen by microbes that utilize sugars (McKain et al., 2010). This could reduce the amount of bioactive fatty acids that have been associated with milkfat depression. Another basis could be the greater amount of butyrate produced from fermentation of sugars than from other carbohydrates (Strobel and Russell, 1986).

Butyrate makes up 30% of the fatty acids in the *sn*-3 position on milk triglycerides (Jensen, 2002), and provides 50% of the starting carbons in de novo synthesis of fatty acids in milk (Palmquist et al., 1969).

Another thing to consider with starch vs. WSC: the polysaccharide (starch) contains more carbohydrate than the mono- or disaccharides do. To put carbohydrates on an equal monosaccharide or free sugar, dry matter basis, the weight of water must be added hydrolyze the bond between sugars to release free sugars. For glucose, a monosaccharide, the free sugar value of 1 lb of glucose = 1 lb of free sugars. For disaccharides such as sucrose which have a single bond between the sugars, 1 lb of sucrose = 1.05 lb of free sugars. For a polysaccharide such as starch which has many bonds, 1 lb starch = 1.11 lb of free sugars.  So, although we treat the carbohydrates as though equal weights have equal value, that is not really the case.  However, it's their fermentation and digestion characteristics that will decide the amounts of products produced that ultimately matter to the cow.

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