

Sweet Options

By Cindy Hazen, Contributing Editor

When a friend recently organized a girls' cabin weekend, she shopped at three different stores to buy just the right ingredients for meals. With the same quest for perfection, she provided a variety of sweeteners for our morning coffee. "Everybody has a preference," she said as she set out sugar, honey, Equal, Sweet'N Low and Splenda.

Most of us have strong opinions about what sweetens our drinks and our foods. Nowhere does this play out more than at the grocery store. And while food technologists must formulate with the label in mind, they also must consider all of the characteristics a sweetener will bring to the product and the way it will be perceived upon eating.

The skinny on sweeteners

All sweeteners are not sugar. Cindy Cosmos, senior flavor chemist, Bell Flavors & Fragrances, Northbrook, IL, believes this is the most-important point for the food scientist to remember.

Sugar, or sucrose, consists simply of disaccharides of glucose and fructose units. It's considered nutritive because it provides 4 calories per gram. Corn syrups and fruit products are also in this category, though have varying levels of sweetness. Dextrose, a glucose isomer, has roughly 0.7 times the approximate sweetness of sugar. The term DE (dextrose equivalent) is commonly used to convey relative sweetness.

Non-nutritive sweeteners contribute little or no calories based on consumption and sweetness levels. They can be derived from plant sources, such as stevia, or they may be synthetic. They are considered "high intensity"; acesulfame K and aspartame are 200 times sweeter than sugar, and steviol glycosides are 200 to 400 times sweeter than sucrose. Aspartame, saccharin and sucralose are artificial sweeteners with a long history of consumer acceptance.

Because of their high levels of sweetness, high-intensity sweeteners "do not have the bulk which provides mouthfeel of sugar-based products," says Cosmos. They also don't taste quite like sugar. "There may be flavor reactions that occur with sweeteners at a chemical level, so masking may be necessary," she says. "Sweeteners can have a lingering aftertaste that is not sweet, but bitter, metallic or licorice, and that has to be masked. Great products can be developed with sweeteners, but they may need to be tested or evaluated in comparison to a full-sugar product."

Sweetness of fruit juice

When it comes to offering the perception of nutritional value, fruits excel. "Natural fruit sweeteners contain varying levels of relative sweetness as compared to pure sucrose," says Bill Haddad, VP, technical services, American Fruit Processors, Pacoima, CA. "Assuming sucrose has a relative sweetness of 1.0, then fructose has a relative sweetness of 1.3 and glucose has a relative sweetness

of 0.7. Depending on the fruit juices selected and blend ratios, one can achieve the desired sweetness level."

Fruit juices predominantly contain fructose, glucose and/or sucrose, which comprise up to 80% of the total solids of the fruit juice. "Natural fruit sweeteners are usually blends of pineapple, peach, pear, apple and/or white-grape juice concentrates. The percent of any of these juice concentrates in a blend is generally developed based on desired sweetness, and other attributes like color, mouthfeel or acidity," Haddad says. Soluble solids range from 68 °Brix to 72 °Brix.

In some formulations, the presence of natural organic acids in fruit-juice concentrates may cause interactions with other ingredients. "Sometimes, one may choose to use an ion-exchanged, fruit-juice-derived sweetener, because most of the acid can be removed by this process. This does, however, also remove minerals and polyphenolic compounds, as well," Haddad says. Maillard reactions in juices are possible due to the presence of reducing sugars, but "in our experience this is not much of a concern," he continues.

Properly storing fruit juices is imperative, because they have a water activity and micronutrients that make them susceptible to fermentation and microbial growth. It's also important to remember that not only does a natural fruit sweetener provide sugar-solids replacement, it also contributes some water to the end product.

It really is corn sugar

Corn sweeteners include corn syrups of varying DE, high-maltose corn syrup, high-fructose corn syrup (HFCS) and dextrose. Corn syrups and corn-syrup solids are produced in a range of DEs to provide sweetness, body, crystallization control and humectancy in applications from confectionery to baked goods to prepared foods. In comparison to sucrose, 28 DE corn syrup has roughly 20% the sweetness of sugar. HFCS (55% fructose) has about 110% the sweetness of sugar.

"Lower-DE corn syrups are valued for high viscosity and binding characteristics, whereas the higher-DE syrups contribute greater sweetness and humectancy," says Heidi Adams, technical service manager, Corn

Sugar vs. HFCS

Even though the differences between sugar and high-fructose corn syrup (HFCS) are rooted in perception and not science, major food manufacturers continue to reformulate products—including such high-profile national brands as Gatorade sports drinks and Heinz ketchup—to make the switch.

For many years, HFCS has been the sweetener of choice in products across the board. One reason for this preference has been based in economics. Imported sugar is more expensive than domestically grown corn, the starting raw material for HFCS.

One product category that continues to rely on HFCS is carbonated soda. Notes Indra Nooyi, CEO, PepsiCo, HFCS is "as clean and safe as it comes," and that this attention paid to replacing it with sugar is "a perception issue."

However, the company has committed to expanding its "non-junk-food" portfolio of products from \$10 billion to \$30 billion over the next decade, and will invest "unprecedented resources" into developing natural, calorie-free sweeteners that taste and perform just like full-calorie versions.

Products U.S., Westchester, IL. "In a cereal or snack-bar application, corn syrup usage may be in the 10% to 25% range, whereas many confectionery applications would utilize corn syrup as roughly half of the formulation."

High-maltose corn syrups are used as an adjunct in brewing operations. For confectionery products, they are valued for their ability to produce hard candies with superb color stability and processing ease.

Dextrose (also known as D-glucose, and what the FDA currently defines as "corn sugar") has a cool, mild sweetness due to its negative heat of solution that can enhance flavor. It also has "a high reducing capacity to support browning," says Adams. "It is 100% fermentable, provides high osmolality and is typically available in a variety of granulation sizes, monohydrate and anhydrous crystalline forms, as well as in liquid form. Dextrose may be used as a partial or complete replacement for sucrose in a variety of applications." It is also often used as a carrier for high-intensity sweeteners.

HFCS has gotten a lot of negative press, but according to the Corn Refiners Association, Washington, D.C., studies show that a limited number of consumers look for it on product labels. "Research also shows that companies that switch from HFCS to sucrose—presumably implying some type of benefit—are not seeing sustained market gains and are negatively impacting consumer impressions and their own economic needs," says Allan Buck, director, technical services, food ingredients, ADM, Decatur, IL. The company offers HFCS ranging from 42% to 90% fructose. Typically 42% and 55% syrups are used for products, although higher-fructose products are used for reduced-calorie foods due to the sweetness level. The amount of fructose determines the level of sweetness. "Based on an equal-weight dry basis versus sugar, with sugar being 100%, our 42% product is 92% the sweetness of sugar and our 90% product is 130%," he says.

64% of Consumers Say HFCS OK in Moderation

A new Mintel survey revealed 64% of U.S. consumers say high fructose corn syrup (HFCS) is acceptable in moderation, while 46% say they really don't know enough about HFCS to know if it is good or bad for their health..

Moreover, 35% of survey respondents avoid products that list HFCS as any ingredient, and 65% of consumers believe manufacturers or brands themselves should be responsible for disclosing how much HFCS a food or drink contains.

The new survey is timely as the Corn Refiners Association (CRA) petitioned the U.S. Food and Drug Administration (FDA) last month to allow manufacturers the option of using "corn sugar" as an alternative ingredient name for high fructose corn syrup. While it's unclear what effects this possible name change will have, consumers are concerned about the controversial food additive.

According to Mintel, 57% of respondents believe it should be up to the government to force company disclosure of the amount of HFCS a food or beverage contains and 44% state retailers should mandate disclosure. Only 16% think disclosure should not be forced.

"Today's consumers are demanding greater labeling transparency across the board," said Krista Faron, lead innovation analyst at Mintel. "And when it comes to an ingredient as controversial as high fructose corn syrup, the majority of Americans clearly want complete information that will help them make informed purchase decisions."

While many consumers think disclosure is important, some seem to draw the line at imposed limitations on HFCS content. Thirty-seven percent of survey respondents say no one should be responsible for imposing restrictions on how much HFCS can be in any given food or drink product; 35% believe the government should limit HFCS content; and 45% think it should be up to manufacturers.

Fructose is soluble to 80% at room temperature. Dextrose is soluble to 50%. All corn sweeteners contribute to Maillard browning. "The reducing-sugar content dictates the rate at which they contribute to this reaction, with fructose, dextrose and HFCS being almost 100% reducing sugars on a dry basis. Our corn syrups are between 26% and 62% reducing sugars," says Buck.

There are many reasons why HFCS is often the sweetener of choice, according to Adams: It can replace sugar in one-for-one proportions, and it enhances many fruit, citrus and spice flavors. HFCS reduces water activity and extends shelf life. In baked goods, it helps retain moisture and resists crystallization after baking. In beverages and condiments formulated with HFCS, sweetness and flavor are unchanged due to storage temperature fluctuations or low product acidity. Because HFCS has a lower freezing point than sucrose, frozen beverage concentrates are pourable straight from the freezer.

Other caloric sweeteners

Trehalose is a naturally occurring disaccharide consisting of two glucose molecules. Compared to sugar, it is 45 DE. Trehalose can sweeten a wide variety of products. Usage varies from 1% to 10% in bakery to 80% in icings. In meat or surimi it's used at less than 2%, and in flavor applications less than 5%.

"Solubility is about 30% at room temperature, increasing to the same level as sugar at 80°C," says Samuel Bartholomew, product manager, Hayashibara International, Broomfield, CO. "It does not participate in Maillard browning." Because it is a non-reducing sugar, it will not react with proteins and remains stable under low-pH conditions.

Honey contains a variety of sugars, including maltose, sucrose, kojibiose, turanose, isomaltose and maltulose, but is comprised primarily of glucose (31% to 44%) and fructose (23% to 41%). Generally, honey is 1 to 1.5 times sweeter on a dry-weight basis than sucrose. On a weight:weight basis, liquid honey (approximately 17% moisture) has about the same sweetness as sugar. Honey also contains about 3% to 4% oligosaccharides, including erlose, theanderose and panose. When combined with low levels of sucrose in solution, honey exhibits a synergistic sweetness effect; the addition of 25% honey to a 5% sucrose solution doubles the intensity of sweetness.

Super sweeteners

Sucralose is 600 times sweeter than sugar. It can be blended with another sweetener, such as fructose, or with fiber or prebiotic fibers. "Sucralose can be used to replace some of a product's sugar content," says Pashen Black, marketing communications manager—Americas, Tate & Lyle, Decatur, IL. This zero-calorie sweetener can replace nutritive sweeteners up to 30% without altering taste. It can be used in products making no-sugar-added, sugar-free or reduced-sugar claims.

Sugar alcohols, or polyols, may be used in products with a variety of sugar levels. "In full-sugar food systems, sorbitol is the primary polyol of use, as it contributes to moisture binding and control at low use levels," says Rick Francolino, food scientist, Corn Products U.S. "When reduced-sugar and no-sugar-added products are desirable, polyols such as maltitol, maltitol syrups, polyglycitol syrups, isomalt or erythritol are typically included to replace sweetness, texture, mouthfeel and processing ability lost when traditional sugars are removed. Additionally, polyols can be included when a reduction in calories is desired."

Compared to sugar, mannitol is about 50% as sweet, sorbitol is about 60% as sweet, erythritol is about 70% as sweet, maltitol is about 90% as sweet and xylitol is about 100%. A laxation label claim may be required when formulating with sorbitol (50 grams per daily intake) or mannitol (20 grams per daily intake).

Sorbitol may be used in confectionery, dairy and bakery products, and some meat applications. Mannitol is used in confection applications, particularly chewing gum. Erythritol is used in beverages. Xylitol and erythritol, like dextrose, have a negative heat of solution and a higher cooling effect than sugar. Xylitol is commonly used in non-chocolate confections, and is especially suited for mint.

Tim Bauer, polyols and dextrose product line manager, Cargill Health & Nutrition, Minneapolis, notes their erythritol has "great synergies with high-potency sweeteners." He notes that it is less sweet than sugar, but it provides bulk to products, such as those made with stevia.

Of the polyols, maltitol's properties are the most similar to those of sugar. This allows for wider application use, ranging from bakery, confections (chocolate and non-chocolate), sauces, icings, bars, dairy systems and tabletop sweeteners. "Maltitol can be used to completely or partially replace sugar, corn syrup, invert or corn-syrup solids," says Andrea McBride, business development, dry

Low-Calorie Foods Driving Global Polyols Sector

Increasing consumer demand for healthier, low-calorie foods is one of the primary drivers fueling the resurgence of the global market for polyols, which will reach £4 billion pounds by 2015, according to Global Industry Analysts' new ["Polyols: A Global Strategic Business Report."](#)

The market is likely to be driven by rising demand mainly in food and confectionery and pharmaceuticals end-use segments. In fact, food and confectionery represents the fastest-growing end-use segment. Food producers are seeking alternatives that reduce calorie content without compromising taste and appearance. Of the several methods adopted to reduce the calorie content in food such as fat replacement, the substitution of commercial sugar with polyols has gained wide application. Though polyols behave similar to sugar in final products, they possess much lower calorie content. With features such as sweet taste and fewer calories than sugar, polyols are increasingly gaining popularity in the food and confectionery segment.

The report provides a comprehensive analysis of the polyols markets, recession trends, current market trends, key growth drivers, product overview, recent product introductions, recent industry activity, and profiles of major/niche global as well as regional market participants. The report provides annual sales estimates and projections for polyols market for the years 2007 through 2015 for the United States, Canada, Japan, Europe, Asia-Pacific, Middle East and Latin America.

polyol, Roquette America, Inc., Keokuk, IA.

Polyols do not have browning properties. "Interactions are minimal in the majority of applications. However, low pH can affect solubility with some products, and recrystallization may be an issue when combining polyols or sugar," advises McBride.

New naturals

Compounds from the stevia leaf are sweetening a variety of foods. Stevia's advantage over other natural mainstream sweeteners is that it contributes no calories to foods and beverages and has a zero glycemic load.

"Each steviol glycoside has a different relative sweetness compared to sugar," says Jason Hecker, marketing director, PureCircle USA, Oak Brook, IL. "Reb A (rebaudioside A), one of the most-abundant glycosides, is up to 400 times sweeter than sugar."

Mariano Gascon, vice president, R&D, Wixon, Inc., St. Francis, WI, cautions that there are other flavor considerations besides sweetness with stevia-based sweeteners. "There are six sweet compounds in the stevia plant, and depending on the extraction method and purification process, the aftertaste can vary. Reb A is the cleanest of all the compounds. But even in high-reb-A products, there is a tiny bitterness and lingering effect that needs to be compensated for," he says.

A highly purified reb-A ingredient, notes Ralf Loeffelholz, commercial leader, Cargill's Truvia™ Rebiana ingredient business, Minneapolis, "is different from stevia used in other applications, which typically refers to a mixture of many components from the stevia leaf." He finds the sweetener most commonly used in beverage applications. However, it is being used in yogurt, ice cream, baked goods and confectionery, "with category product launches, such as jams, in the near term. Typical use levels range from 0.02% to 0.06% as consumed, or higher in special applications such as sugar-free hard candy," he says.

Stevia extracts and reb A are highly soluble and have no browning reaction. Loeffelholz notes that his company's stevia sweetener "will dissolve instantly in water to produce solutions in excess of 30% weight by volume but, at room temperature, these crystallize over time. The true equilibrium—the concentration that won't crystallize—is 0.8%," he says. It is also heat- and pH-stable in foods and beverages.

Soft Drink Makers Exploring Stevia, Neotame

Major soft drinks suppliers including PepsiCo and Coca-Cola have been developing products sweetened with stevia, according to a new report from Leatherhead Food Research that reveals the market for intense sweeteners grew by nearly 19 percent between 2007 and 2009. The report also stated that Neotame is also poised for growth, having recently gained regulatory acceptance in the European Union.

"The Global Market for Intense Sweeteners" report discusses applications and regulatory status of aspartame, sucralose, acesulfame K, cyclamate, saccharin, stevia and neotame. Information also includes a review of trends in end-user markets, as well as profiles of the world's leading suppliers and a discussion of significant regulatory and technical trends.

"At low concentrations," Loeffelholz says, the reb A sweetener "enhances flavors and is recognized as FEMA GRAS at concentrations up to 0.003% (0.020% in chewing gum) for this purpose in a wide range of products." He also notes that it is "powerfully synergistic with many other sweeteners, both caloric and noncaloric, and can be used to enhance the sugar-like taste of synthetic zero-calorie sweeteners, too. There are no adverse interactions with other ingredients."

Flavorful considerations

It's important to consider the way sweeteners are perceived. "Stevia alone has a late onset of sweetness, lingers in the sweetness, and has off notes such as earthy, licorice and bitter notes," says Jessica R. Jones-Dille, senior manager, industry trends & market research, WILD Flavors, Inc., Erlanger, KY. "By utilizing taste-modification technologies, formulators can improve on the upfront sweetness and add body and mouthfeel that is lost when sugar and other sweeteners are removed or reduced, while blocking the off notes that are associated with stevia."

Gascon finds that products that have some acidity are easier to work with, because acids and stevia have a nice effect together. "Less-acidic products like vanilla or coffee may present a challenge that would require the usage of either a combination of sweeteners and/or taste modifiers to simulate a sweetness similar to sugar," he says.

Stevia's synergistic effect in citrus-based products is evident in products such as Coke's Sprite Green, says Cosmos. However, distinct flavor nuances are not always perceived in some stevia-sweetened systems. "Flavor blends may be needed," she says.

Beverages are more challenging to sweeten because of the aftertaste of some sweeteners. "Confections requiring high heat may limit the use of some high-intensity sweeteners," Cosmos says. "Chocolates may also require the use of sugar alcohols for bulking to create a better mouthfeel, but the interaction of sugar alcohols when used to fill in the bulk or density of a product can produce off tastes."

Creative flavor chemistry—and for that matter creative product development—is required to bring a reduced-sugar product back to the profile of a full-sugar system. For that matter, creativity and know-how are required to match sweetener systems to the tastes we know and love.

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