FOOD PRODUCT DESIGN®

Seamlessly Sugar-Free Sweets

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In today's economy, the confectionery industry overall is doing reasonably well, but sugar-free confectionery is experiencing a lull—with the exception of sugar-free chewing gum, which continues to see double-digit increases in sales year after year. We can, however, expect to see sugar-free and reduced-sugar confectionery sales increase overall as the economy recovers—especially since the taste of sugar-free and reduced-sugar products has improved substantially over the last decade as suppliers and formulators have collaborated to raise the sensory bar on these products.

Sugar-free vs. reduced-sugar

The primary building blocks of food sugars are the monosaccharides glucose, fructose and galactose. The structure of each of these sugars is completed by one of two functional groups, an aldehyde or ketone. These functional groups interact with other ingredients, such as protein, to create familiar products like caramel. Monosaccharides can also be linked with other monosaccharides to form what are called disaccharides (i.e., consisting of two sugars). The most common disaccharides found in confectionery applications are sucrose, maltose and lactose. Of these sugars, sucrose is probably the most widely used in the making of candy. It is the standard for all other bulking ingredients and high potency sweeteners to meet.

"Reduced sugar" products can be the easiest to formulate. Only a portion of the sugar needs to be replaced to meet the claim. And since the majority of the sugars are still allowed to be used, these products often retain much of their desirable characteristics and functionality when finished.

Consumer sensory expectations of confectionery are based on full-sugar products, so any sugar-free or reduced-sugar product would ultimately need to meet those same expectations. As a result, understanding the basic functional aspects of sugar and corn syrup in confectionery applications is a necessity for the product designer.

The functional gold standard

Many confectionery characteristics are based on the amount of sugar crystallization, or "graining," in the product. To replace sucrose in a grained application such as fudge, you need to find a sugar-free ingredient that can provide similar solubility and crystallization properties. Sucrose has excellent solubility in water, and confectioners have been trained to work with its crystallization rate and qualities. Often, to meet those expectations, formulators need to work with several sugar-free ingredients and may need to "seed" (add crystalline product) the process to accelerate crystallization. Hard candies can be grained (as in a product made with sucrose and/or corn syrup, or an isomalt product) or they can exist as an amorphous glass. In the latter case, molecular weight is a key element in elevating the glass-transition temperature to a level which does not allow "cold flow" of the product during shelf life.

Sucrose has a molecular weight (MW) of 342 grams per mole. In the world of carbohydrates, this is considered somewhat small. The typical characteristics of smaller molecules, like the mono- and disaccharides, are that they tend to crystallize more readily, have less viscosity and provide greater humectancy by binding water more effectively. This is why, for example, confectioners use more sugar than corn syrup in their "grained" candy formulations. It allows them to get optimal crystallization.

Larger molecules that tend not to crystallize increase viscosity, and they provide little to moderate humectancy in comparison. In confections, these larger molecules provide the chewy texture in taffy, the stringing seen in soft caramels when pulled, or the viscosity needed for efficient hard-candy production. They also are used in various ratios to effectively control crystallization of sugars, such as sucrose, in applications ranging from gummy candy to fudge. Many ingredients used in confections, such as fat or protein, add molecular weight. But, in most cases, the main ingredient that provides these characteristics is corn syrup, and by varying the amount of corn syrup (and its dextrose equivalent) used with sugar, we can significantly affect the characteristics previously mentioned.

Replicating with polyols

Polyols are some of the most-versatile sugar-free ingredients available, especially for confectionery products. The reason for this becomes clear when examining their origin.

In the United States, polyols start out as traditional corn syrups modified by reducing the reactive sites (aldehyde or ketone) through either one or a combination of the following production methods: catalytic hydrogenation, enzymatic conversion or fermentation. Only the reactive groups are changed, so the polyol retains much of the sugar's structure, bulk and function. Moreover, all of the polyols are considered either a food additive, GRAS or self-affirmed GRAS.

Polyols can be divided into three groups: monomers, dimers and polymeric mixtures. The monomers—consisting of one carbohydrate unit—are erythritol, mannitol, sorbitol and xylitol. The dimers—consisting of two bonded carbohydrate units—are isomalt, lactitol and maltitol. The polymeric mixtures are combinations of polyols—varying in lengths of repeating carbohydrate units—that are identified as polyglycitol syrups, also known as hydrogenated starch hydrolysates (HSHs) and maltitol syrups, which are the most similar to corn syrups. Nomenclature is determined by the amount of maltitol present on a dry basis; a syrup that contains greater than 50% maltitol is considered a maltitol syrup, and anything less is a polyglycitol syrup.

Polyols can exhibit a wide range of physical characteristics beyond that of the typical solubility, molecular weight and sweetness. They have other unique properties, such as cooling effects, which occur when crystalline polyols—exhibiting a negative heat of solution (erythritol, xylitol, and mannitol have the most notable cooling effects)—are dissolved in water (often reducing the temperature of its surroundings). This may be a welcome property in an application such as mints or breath-freshening chewing gum, but not necessarily in traditional dark chocolates.

Another unique property of polyols is their absence of reducing groups, which allows them to be very heat-stable (up to 350°F). In hard-candy applications, this is considered a benefit because they produce no off colors (yellow) or off flavors like traditional sugar products. On the other hand, in applications such as caramel, polyols do not react with protein (i.e., Maillard reaction) to produce those desired caramel colors or flavors. Lastly, not all polyols are digested in the same manner, and some are better-tolerated than others. Erythritol is well-tolerated, as are the higher-molecular-weight maltitol syrups and polyglycitols. Given the choice of multiple polyols, the serving size can dictate which is better suited. For example, chewing gum has a much-smaller serving size than that of gummy candy—typically 5 grams vs. 40 grams—so a lesser-tolerated polyol would be more appropriate in the chewing-gum product.

Substantial and (a bit) sweet

Another group of bulking ingredients is the "fiber" or "fiber-like" low-digestible carbohydrates. These carbohydrate polymers (higher molecular weight) consist of sugars—such as glucose, mannose and fructose—linked together in such a way that significantly reduces their digestibility, as well as caloric contribution. Their sources are various and they can be naturally occurring or man-made. Although these can be used to help obtain a "sugar free" claim, some of them can add another claim: fiber. Depending upon how much fiber is used in the finished food, FDA allows for various types of fiber-related claims where the product can be considered an "excellent source" (5.0 grams of fiber per serving) or "good source" (2.5 grams of fiber).

Polydextrose has an accepted caloric value of 1.0 kcal per gram and works very well with the lower-molecular-weight polyols, contributing viscosity without adding calories. Polydextrose is hygroscopic and can easily pick up moisture. This is a great property for controlling water activity and shelf-life in certain applications, such as meal and snack bars, and fudge. But, in something like hard candy, this water-loving property could be counterproductive by increasing stickiness and limiting shelf life. Knowing the requirements of the application will help the product developer understand where this ingredient can provide the most benefit for a finished candy.

Inulin defines a group of low-digestible carbohydrates found naturally in many sources, such as agave, onions, bananas, asparagus, garlic and Jerusalem root, although commercial sources are primarily produced from chicory root and agave. It is self-affirmed GRAS and has a caloric value between 1.0 and 1.2 kcal per gram. Inulin

POLICY STATEMENT

Clarifying the Claims

According to Title 21 of the *Code of Federal Regulations (CFR)*, Part 101, Section 9(c), sugars are defined as "the sum of all free mono- and disaccharides (such as glucose, fructose, lactose and sucrose)." For a "sugar-free" label claim, the finished product would need to contain less than 0.5 grams of sugars (21 *CFR* 101.60(c) (1) (i)).

In addition—because consumers expect that anything sugar-free must also be lower in calories—the finished product is often labeled either as a "low-calorie" or "reduced-calorie" food. If it is not a "low-calorie" or "reduced-calorie" product, then it requires a statement such as "not a reduced-calorie food," "not a low-calorie food" or "not for weight control."

The FDA allows "without added sugar" and "no added sugar" to be used, as well. A good example of a product likely to carry such a label would be caramel, where the milk solids used contain enough naturally occurring lactose (even with all the other sugar and corn syrup removed) to still not meet the requirements for "sugar free."

For "reduced-sugar" products, FDA allows for a 25% reduction in sugars per reference serving size when compared to that of a full-sugar equivalent (21 *CFR* 101.60(c) (5) (i)). In addition, the label must include information on the identity of the reference food, the percent or fraction of sugar reduction, and the amount of sugar in a standard or full-sugar product.

is composed of fructose molecules linked together, ending with a glucose molecule, to form polymers of various lengths—ranging anywhere between 2 and 70 units long. When the polymers are broken down to the point where they range from 2 to 10 units in length, they are referred to as fructooligosaccharides (FOS). They can also be built up from sucrose, as in the case of short-chain fructooligosaccharides (scFOS). Typically, the smaller the polymers, the more soluble and sweet they become. Also, depending upon the source, inulin can be either highly branched (as in agave) or linear. As a result, the more branched the polymers, the more soluble they will become—up to 230 grams in 100 grams of water—but they still offer slightly less viscosity than linear polymers.

Resistant maltodextrin is metabolized dramatically slower than traditional maltodextrins, reducing its effect on elevating blood glucose levels. Although scientific data indicates resistant maltodextrin ranges from 1.0 to 1.5 kcal per gram, in the United States it is still considered 4.0 kcal per gram. The molecules of resistant maltodextrin are typically large in size and highly branched. This allows them to be very soluble while contributing viscosity comparable to that of traditional maltodextrin in applications like meal and snack bars, as well as hard and soft confectionery.

A sweet boost

Most of these bulking agents are less sweet, some considerably less, than sucrose. In most cases, the product designer must consider adding one or more high-potency sweeteners (HPS) to supplement the loss of sweetness.

In the past decade, formulators have gotten creative in their use of combinations of approved nonnutritive sweeteners and sweetness enhancers. Although many types of HPS exist, only a few are approved for use as a sole source of sweetness in the United States: saccharine, sucralose, acesulfame K, aspartame, neotame and rebaudioside A. Of these, the HPS most often used in the confectionery industry are aspartame, acesulfame K and sucralose, due to cost and ingredient synergy. Neotame has been used primarily in pressed mints and chewing gum. Acesulfame K is heat-stable and has an early sweetness onset, which combines well with the lingering sweetness of aspartame and sucralose. Aspartame has limited stability to heat and acidity, so it is usually added late in a process or at elevated levels. An example of this would be in hard candies, where aspartame is added post-cook, prior to the cooling table.

The new sweetener for consideration is rebaudioside A, a highly sweet (200 to 300 times sweeter than sucrose), natural steviol glycoside isolated from the leaf of *Stevia rebaudiana* (Bertoni), a plant found in South America, but now grown in several countries. Late last year, two companies received GRAS notification letters from FDA for the sweetener's use in food and beverages, and several other companies have self-affirmed GRAS. Rebaudioside A has excellent heat and acid stability, as well as good sweetness at prescribed use levels. This stability makes it a good candidate for all confectionery applications. Any bitterness at higher use levels can often be countered with other (bulk) sweeteners, addition of other flavors, or adjustment of typical acidulants. Rebaudioside A has successfully been used in hard candies as the sole sweetener (polyglycitol syrup supplying the bulk of the product), although much of its initial use has been in beverage and tabletop applications.

Over the last decade, the range of options has made the migration of full-sugar to sugar-free or reduced-sugar an easier one for the product developer, resulting in better, more-appealing products. A combination of better understanding of the ingredient's chemistry and its role in the end-product's characteristics through supplier-customer teamwork can lead to lower-calorie, better-tasting confectionery for consumers.

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