

## Keeping Beverages Sweet Without the Sugar

By Lauren Curtis, Contributing Editor

The original no-sugar beverage was, of course, water, easily accessible at the local stream or town well. If you were thirsty, there were no choices, just pure (sometimes) cool (hopefully) water. With the advent of modern technology, safe drinking water became available in the home. Yet somehow, over time, water's share of the beverage market slowly eroded in favor of other beverages, including fruit juices full of naturally occurring sugars and carbonated, sugar-laden soda pop. Why did water lose top billing in the beverage market? After all, it was pretty inexpensive and widely available. Could it be that water is so thin and flavorless and well ... watery?

Nowadays, choices of thirst-quenching beverages abound. So much so that consumers must decide what type of a drink they are in the mood for, then which aisle to peruse in the local grocery store: The juice aisle, the soda aisle, or the natural foods section? There's even a water aisle; it doesn't just come out of the faucet any more. And as times change, the demand for lower- or no-sugar versions continues to rise.

### Fizz meets sugar

Back in 1772, Jacob Priestly had no idea how his discovery, artificially carbonating water, would impact the beverage business. By 1865, 15 sweetened and flavored sodas were on record. The first widely used sweetener was sugar made from sugar cane or sugar beets. In the 1960s, corn syrups entered the scene, and by the 1980s, high-fructose corn syrup (HFCS) became the preferred sweetener in the U.S. beverage market.

As these beverages became easily accessible in convenience stores, fast food restaurants and vending machines, per capita consumption rose, and they became linked, rightly or wrongly, to an increasing incidence of obesity and diabetes. HFCS itself has been attacked, with critics claiming it single-handedly caused the obesity epidemic. Since the majority of soft drinks use HFCS, it is easy to make this unsubstantiated claim.

Due to these types of media reports, efforts are underway to prevent the sale of sugary sodas in schools across the United States. In some states, the lawmakers have been successful. Add the low-carb craze and rising interest in healthier options, and it provides both big conglomerates and small start-up companies with an opportunity to design and market beverages for a population with a growing concern for nutrition and wellness. The most powerful weapon they have on their side is choice. Not only are consumers more accepting of alternate sweeteners, they are demanding them. Between the 24 hour news channels and the Internet, the amount of information—whether fact based or anecdotal—is staggering. As the public has become more informed, they are looking for products without HFCS or sucrose and asking for alternate sweeteners to reduce calories, carbohydrates and impact on blood sugar.

The amount of sugar in a full-sugar beverage, whether a soft drink or a juice, can vary between 24 and 34 grams per 8-oz. serving. The beverage industry measures the amount of sugar in a beverage by the Brix scale, named for the German scientist Adolf F. Brix. He invented a hygrometer that can determine the percent sugar solids in solution at a given temperature, typically 20°C. Using this scale, the Brix for most full-sugar beverages fall between 9.7°C and 13.5°C.

What then is a low sugar beverage? Any beverage, to be classified as low sugar, must have a minimum of 25% less sugar than the full-sugar offering. When labeling, manufacturers must reference the comparison

full-sugar beverage in close proximity to the low-sugar claim and list the percent reduction as well. According to Debby Poskanzer, senior manager, consumer insights, Wild Flavors, Inc., Erlanger, KY, Mintel Global New Products Database reported a total of 160 “No/Low/Reduced Sugar RTD Juices & Juice Drinks” were launched last year. Under a separate heading, 77 “No/Low/Reduced Calorie RTD Juices & Juice Drinks” were launched; however, it is likely there was some overlap in the categories. She says: “The No/Low Sugar Beverage market is synonymous with no/low calorie beverages, and many companies utilize the terms interchangeably, depending on their marketing strategy and the consumer they are targeting. Some companies do not want to remove all of the sugar in an effort to be able to balance calories with taste, therefore utilizing a combination of low calorie content (10, 20 and 30 calories per serving) with an artificial sweetener boost.”

So, if starting with a sugar content of 24 to 34 grams per 8-oz. serving, a product designer must reduce the beverage’s sugar to between 18.0 and 25.5 grams. This still contributes 70 to 99 calories per serving. (In lay terms, this translates to 4 to 6 teaspoons of granulated sugar.) Fewer calories than full sugar for sure, but it still packs a caloric punch.

### **Design considerations**

To formulate a beverage, the first requirement is a fluid medium, which brings us back to water. Flavor is an important component of any beverage. Flavor comes not only from flavor oils and flavor chemicals, but also from sugar—more as an enhancement of the flavor than actual flavor itself. But if you’ve vowed to forsake sugar and develop a healthy beverage, product designers have a variety of nonnutritive sweeteners to choose from: aspartame, acesulfame potassium and sucralose, to name a few. Now remember, you may actually be designing a low-sugar beverage and as such, some sugar is not out of the question. Don’t forget about the sugar alcohols, they are a sweetening resource as well. Now that you have that taken care of, what else will you need? Some acid helps to balance the flavor and add some degree of protection to the product by reducing the pH. Speaking of protection, how about some preservatives so this delicious new beverage has a shelf life greater than a glass of milk, but somewhat less than a fruitcake? Most soft-drink producers use sodium benzoate to take care of any lurking yeast and bacteria. What about the addition of some fruit juice or purée? This will add a triple whammy of sugar, flavor and mouth-feel. Not adding fruit juice but still want some mouth-feel? Try soluble fibers, pectin and gums. For a little extra nutrition, add some whey protein to a smoothie application. Last, but not least, consider color. Since most people buy with their eyes, this delicious, nutritious beverage needs some eye appeal; you just need to decide what type of color will fit the bill.

### **Water, water everywhere**

The type of water is the first consideration. Do you want spring water, purified water, distilled water or perhaps some high-tech-sounding reverse-osmosis water, or vapor-distilled and/or deionized water? Label and marketing factors aside, the composition of water is important due to the interactions that can occur with impurities.

Water is not only composed of hydrogen and oxygen, but various other minerals and salts, which govern whether the water is considered hard or soft. In addition, depending upon its source, it can contain numerous other impurities: organic matter, algae, bacteria, protozoa and other solids.

The water’s origin will dictate the extent of treatment required to use it for beverage production. Ground water, as its name implies, is found below the ground in aquifers and natural springs, and is historically a purer source of water—though it is becoming more susceptible to contamination by industrial waste. Labeled as spring water or natural mineral water, it only undergoes minimal treatment, enough to ensure its safety. Surface water represents water from reservoirs, lakes and the like, has undergone extensive treatment and is likely labeled

purified, distilled, reverse osmosis, deionized or simply 'water.' While municipally treated water is safe to drink, it does not go through the rigorous purification needed for beverage production including, but not limited to, filtration (nano, ultra and micro), UV radiation, reverse osmosis and ozonation. Residual particulates can adversely affect beverage quality and safety. Excessive alkalinity will reduce the effect of added acids, like citric or malic, and affect the flavor profile. Even byproducts of certain algae can produce a musty off odor or flavor.

## **Sugar, honey?**

Sugar is traditionally next on the ingredient statement. What is sugar exactly? Monosaccharides are the simplest form of carbohydrate; they can not be hydrolyzed to a smaller unit. Nutritive sources of monosaccharides are typically composed of six-carbon unit also known as hexoses. Glucose, fructose and galactose are common monosaccharides. The joining of two monosaccharides creates a disaccharide, the most common of which are sucrose, lactose and maltose.

According to Title 21 of the Code of Federal Regulations (CFR), Section 101.9, sugar is defined as "the sum of all free mono- or disaccharides" from any source, although consumers commonly use it as a synonym for sucrose. Sucrose is a disaccharide composed of one molecule of fructose and one molecule of glucose. Either in its disaccharide form or as its individual monosaccharide form, sucrose, glucose and fructose all contribute sweetness. Fructose has the highest relative sweetness level of the three, followed by sucrose and then glucose. Sucrose is the standard typically measured at 100. Fructose is gauged at 140 to 170, while glucose is only 70 to 80.

Sugar can come in various other guises. On the supermarket shelf it is easy to find as granulated white sugar or brown sugar, and is labeled as such. But what else is considered sugar? Other sources of mono- and disaccharides include corn syrup, HFCS, invert syrup, barley syrup, brown rice syrup, honey, molasses and, last but not least, fruit concentrates and fruit juices.

A certain percentage of the population believes less-purified sources of sugar, such as brown rice syrup, barley syrup, honey and molasses, are better for you. While they may contain trace minerals not found in refined white sugar or corn syrups, they are essentially just sources of mono and disaccharides, which, like any other, will be processed in the body and enter into the energy cycle. If, like any other energy source, they are not used immediately or stored as glycogen, they will, yes brace yourself, will be stored indefinitely as fat.

Fruit juices and purées are also thought to be healthy alternatives to refined sugar. Many juice products, whether pure juice or juice blends, consist of 100% juice, (fresh or concentrated) proudly state on the label, "no added sugar." In a sense that is true. No one added a purified source of mono- or disaccharides, otherwise known as "extrinsic" sugar; but, the body treats intrinsic sugar exactly the same. However, the added value of the fiber, vitamins, minerals, and countless phytochemicals and antioxidants means adding fruit juices and purées as a source of sugar makes better nutritional sense.

Every fruit juice has a standard of identity that is determined by the amount of sugar found in the original fruit. Fruit juices and fruit juice concentrates are essentially sugar solutions extracted from the whole fruit. The method used to determine the concentration of sugar in solution is the Brix scale, as discussed earlier. The standard of identity for fruit juices is then defined as the degree Brix of the single-strength juice.

There is a slight difference between fresh juice and juice from concentrate standards of identity, but since water is heavy and therefore expensive to ship, most producers use juice from concentrate. For example,

reconstituted apple juice in the United States has a Brix value of 11.5°, or roughly 29 grams of sugar per cup. Other common juices have similar sugar contents. Orange juice from concentrate has a Brix of 11.8°, or 29.5 grams of sugar, while peach juice from concentrate has a Brix of 10.5°, or 26 grams of sugar. Accordingly, if 50% of an 8-ounce beverage is peach juice, it contains only half the amount of sugar found in a serving of peach juice, or 13 grams. Then with some added flavor and perhaps a hint of high-potency sweetener you've developed a healthier, refreshing lower-sugar juice drink.

Fruit sugar makes an economical alternative to fruit juice concentrates. Fruit sugar is essentially fruit juice stripped of its flavor, color and acid, according to Bill Haddad, vice president of technical services, American Fruit Processors, Pacoima, CA, "composed predominantly of fructose, glucose and some sucrose; it is not low in carbohydrates but is a natural source. If used in conjunction with nonnutritive sweeteners, such as sucralose or aspartame, you can add some natural sugar and have it take away the artificial aftertaste. You can add 10 to 20 calories and get a good taste profile and low-carb designation. The benefit of fructose is there is no immediate effect on blood sugar, as it takes time to be converted to glucose in the body."

If you prefer everything but the sugar from fruit juice, that is available, too. By "pulling all the sugars/carbohydrates out of the fruit," says Haddad, and leaving the nutritionally beneficial components behind, you "can add back and double the nutritional benefits without doubling the calories." Currently used by the nutraceutical industry as a supplement, this ingredient has yet to find a home in the beverage industry as manufacturers are not sure how to handle the labeling issues.

### Sweetness and taste profile

Pure cane sugar has a delightfully sweet taste that for years was considered the gold standard. Eventually, HFCS took over as lead sweetener, first in beverages and then other areas, changing the sweetener flavor profile most-commonly experienced by the public. According to the Corn Refiners Association, Washington, D.C., crystalline dextrose hydrate was introduced in 1921. Eventually, corn syrup, initially glucose-based, was produced, and in 1968, HFCS became available on the market. After years of process refinement, HFCS secured an economical advantage over granulated sugar and in the 1980s became the nutritive sweetener of choice in the beverage industry.

The name HFCS can be a bit of a misnomer, as it contains 45% to 55% fructose, which is essentially the same amount of fructose as sucrose. The original corn syrups were primarily glucose, so when syrups containing fructose were developed, the name was changed to reflect the difference. HFCS also differs from sucrose in that it contains maltose and other higher-molecular-weight saccharides.

During the middle part of the last century, as people became more weight conscious, artificial-sweetener taste profiles became acceptable and became the preferred profile of the diet drinker. According to Brendan Naulty, vice president sales and marketing, Ajinomoto Food Ingredients, LLC, Chicago, "In blind taste tests with 8°Brix or higher beverages, consumers pick the aspartame-sweetened one and tell them it is the one with sugar." This is clearly an opportunity for nonnutritive sweeteners to offer a very sweet product without the calories (or guilt) from sugar.

Artificial sweeteners are synthe-sized in the lab and generally not found in nature. They range from 150 times to 20,000 times sweeter than sucrose and are consequently referred to as high-intensity sweeteners. The first to be discovered, in 1878, and approved for use in beverages was saccharin. Over the next 125 years, five more artificial sweeteners—cyclamate, aspartame, acesulfame potassium, sucralose and neotame—were discovered and approved for beverage use.

By 1907, saccharin was being used as a sugar substitute, and sodium cyclamate was added to the list of sweeteners in 1951. Both were used in diet products until the 1970s, when some poor rat ended up with bladder cancer, and it was “*sayonara cyclamate!*” Saccharin almost suffered a similar fate in 1977 but was never officially banned; instead, it carried with it a warning label: “Use of this product may be hazardous to your health.” This banner is no longer required, although a few companies do continue to carry it on their labels.

It wasn't until the 1980s that FDA approved other sweetening options. Aspartame (150 to 200 times sweeter than sucrose) was OK'd in 1981 and acesulfame potassium (150 to 200 times sweeter than sucrose) in 1988. Until recently, most diet drinks were sweetened with a combination of aspartame and acesulfame potassium. For years, these two were found together in zero-calorie drinks, taking advantage of their synergistic nature, which allowed for greater sweetening power, subsequently giving a reduced usage rate and fiscal advantage. That is until the advent of sucralose. Sucralose, approved in 1998 (600 times the sweetness of sugar), and neotame, approved in 2002 (8,000 times the sweetness of sugar), are the newest contenders. Sucralose came into the ring swinging, while neotame was more mild-mannered.

Sucralose is the only sweetener that can claim sucrose in its genealogy. It is made by substituting three chlorines for an equal number of hydroxyl groups on the sucrose molecule, rendering it calorically challenged. Since its debut, it has quickly replaced other artificial sweeteners by claiming to taste more like sugar; this claim is made by most high-potency sweeteners but, apparently, consumers more widely believe it due to its lineage. Like the original duo, sucralose is often paired with acesulfame potassium for an economic benefit.

Neotame, like aspartame, combines two amino acids, aspartic acid and phenylalanine. Unlike aspartame, it does not need to carry the warning for phenylketonuria, a genetic disorder found in certain people who cannot metabolize phenylalanine. Neotame is so sweet it only takes about 6 mg of neotame to sweeten a 12-oz. serving, according to the neotame website ([www.neotame.com](http://www.neotame.com)). It can act as a flavor masker for soy and vitamin- and mineral-enhanced beverages at a level below the sweetening threshold. In addition, the website claims neotame can enhance the strength of lime oil, cinnamic aldehyde and vanilla notes in cola-type applications.

New high-potency sweeteners continue to be researched while an old one is struggling to regain its foothold. Cyclamate is attempting to win its way back into the good graces of the FDA and is still under review along with another potential sweetener, alitame. In addition, according to Naulty, Ajinomoto plans to file an application for another high-intensity sweetener with the FDA in 2006. Currently known only by its lab name, ANF 9801, this super-intense sweetener is 20,000 times sweeter than sucrose.

And don't count aspartame out of the game; Ajinomoto is building another manufacturing facility in Japan, which Naulty calls “a **necessity** as the (aspartame) market continues to grow.”

### Calories still count

Pure carbohydrates and proteins (amino acids) contain 4 calories per gram. Granulated white sugar contains 3.87 calories per gram, and one teaspoon of sugar weighs 4.2 grams. The beauty of artificial sweeteners is that even if their carbohydrate or protein content makes them calorically equal to sugar, their sweetness intensity allows for miniscule amounts to be substituted for sugar. Most diet drinks contain no sugar, but even those that contain 2 grams of sugar stay under 10 calories in every serving instead of the typical 100 calories.

The plethora of diet books and theories that have bombarded the public in the past few years have focused on carbohydrates—how to cut them out of the diet, or at least control their consumption. While sugar and calories

are considered equals in terms of energy, when discussing blood sugar they are distinctly different. One diet theory that the public has given a lot of attention to involves the glycemic index. A low-glycemic carbohydrate (desirable these days) cannot significantly raise the blood sugar immediately after ingestion. Simple carbohydrates or easily digested and absorbed sources of glucose raise the plasma glucose level, which in turn raises the insulin level. This is an issue for diabetics who either do not produce enough insulin or in whom the insulin has lost its effectiveness.

This concern over an elevated glycemic response has added another choice to the sweetening arsenal, the sugar alcohols, or polyols. These carbohydrate-based sweeteners are neither sugars nor alcohols but compounds that resemble the two, hence the name. A definition in 21 CFR, Sec. 101.9 describes sugar alcohols as “the sum of saccharide derivatives in which a hydroxyl group replaces a ketone or aldehyde group.”

Using these sweeteners provides many advantages, one of which is that these carbohydrates do not cause an immediate rise in plasma glucose. A second bonus is that as nutritive sweeteners they don't immediately carry the stigma of “artificial” or “chemical” many attach to high-potency sweeteners. Although they are carbohydrates, they do not contribute the usual 4 calories per gram. Due to their inability to be fully metabolized, they contribute only between 0.2 and 2.6 calories per gram, depending on the ingredient. Mannitol, erythritol, sorbitol and xylitol are all monosaccharide sugar alcohols, or polyols. Maltitol and lactitol are disaccharide polyols. The perceived sweetness of sugar alcohols ranges from 30% to 40% as sweet as sugar for lactitol, to a sweetness equal to sucrose for xylitol.

For beverage applications, maltitol is probably the best choice. “Maltitol is 90% as sweet as sugar and has the same osmotic characteristics of a disaccharide like sugar,” says Ron Deis, vice president of technology, SPI Polyols, Inc., New Castle, DE. “Using maltitol syrups in place of corn syrups can decrease both the amount of sugar and amount of calories per serving with sugar alcohols.” Using high-potency sweeteners in conjunction with polyols allows the design of a beverage using the most positive aspects of each ingredient. “Polyols also contribute bulk and mouth-feel to the beverage, a component that is lost when high-potency sweeteners are the sole source of sweetness,” Deis adds.

A disadvantage of polyols is their laxation effect; as such, they have a maximum usage level. According to Deis, “as a rule of thumb, the maximum quantity of an added disaccharide polyol is 15 grams per serving, while the maximum quantity for a polysaccharide polyol is 20 grams per serving. Many consumers choose to consume more than one serving, and these levels take that into consideration. The goal should be to remove as many calories or grams of sugar per serving as is possible without sacrificing taste or texture. These goals are possible using the right mix of ingredients.”

Like the polyols, tagatose is another reduced-calorie sweetener alternative for low-carbohydrate beverages that won't significantly impact blood sugar. Tagatose is made from lactose and contributes only 1.5 calories per gram. It pairs well with other nonnutritive sweeteners, covering the bitterness of acesulfame potassium, increasing sweetness onset when paired with sucralose, and reducing the lingering aftertaste of some artificial sweeteners.

Trehalose, another sweetener that works well with artificial sweeteners, is a disaccharide composed of two glucose units. It is digested slowly and won't raise blood glucose levels or trigger an insulin rush. Like sugar, it contributes 4 calories per gram, and although it is only half as sweet as sucrose, its flavor-enhancement characteristics combined with the low glycemic response make it a good partner for low-sugar beverages.

Sugar plays an important role in the enjoyment of a beverage and, when removed, its loss is felt, literally. Not only does sugar, in its various forms, contribute sweetness and flavor enhancement, it can be the sole contributor to body or mouth-feel. Thus, when removed, the resultant beverage takes on a thin and unsatisfying character.

### Body in bulk

Another ingredient in the low- or no-sugar beverage developer's cache is fiber. Sources of fiber suitable for beverages are polydextrose, inulin and resistant starches. Not only can they provide a necessary nutrient, they will help to modify the mouth-feel in products lacking sugar solids. Donna Brooks, product manager of Litesse, Danisco Sweeteners, New Century, KS, says Litesse, a descendent of the first generation polydextrose, "is a highly soluble specialty carbohydrate that adds body to lowcalorie and sugar-free noncarbonated beverages. It is 90% prebiotic (soluble) fiber that can improve digestive health. Litesse is a clean-tasting, sugar-free fiber that contributes only 1 calorie per gram and is suitable for diabetics." While it adds no sweetness, it is compatible with sugar or high-intensity sweeteners. She goes on to say, "It's an ideal fiber for clear beverages, owing to its high solubility (80% w/v at 20°C), which is greater than most polyols and carbohydrates, including sugar (67% w/v at 20°C)." This is essential in order to allow enough fiber in the beverage to make a claim. She continues, "2.5 grams of fiber per serving is required for a 'good source of fiber' claim, while 5.0 grams is required for a 'high in fiber' or 'excellent source of fiber' claim." The use of Litesse Ultra in combination with a blend of aspartame and acesulfame produced a beverage that was found to be "more mouth-coating and exhibit a mouth-feel closer to a sugar solution," she adds. In addition, polydextrose helps minimize the bitterness and astringency associated with artificial sweeteners.

Pectin, a more potent viscosity-enhancing ingredient is a naturally occurring soluble fiber sourced from apples and citrus fruits with gel-forming properties. At a low usage rate of 0.1% to 0.2%, fruit-based drinks can have increased mouth-feel without turning into Grandma's homemade jam. Other gums, such as carboxymethyl cellulose, will also provide mouth-feel, again at very low levels of 0.2%.

### Strength training

The beverage developer can also look at another low-sugar nutrient: whey protein. According to Sharon Gerdes, technical consultant, Dairy Management™ Inc., Rosemont, IL, "Whey protein isolate is ideal for low-sugar beverages. In a recent human study it was proven that whey protein helped to build and maintain muscle mass. Here, dairy delivers a triple play: flavor, function and nutrition."

Because whey protein contains very little fat or lactose, it can work for clear beverage products. In fact, Gerdes says, "the clarity increases as the pH decreases. You can easily put 2 grams of protein per ounce at pH 3.0 under hot-fill conditions. This is a significant amount of protein, and you can even make a claim of a 'good source' of protein. Here you maximize the benefit of the beverage by decreasing the sugar and providing a good source of protein."

Whey protein concentrate can also be added to smoothies. This type of beverage development is slightly more complicated, requiring the addition of stabilizers and buffers. The pH of these dairy products is higher, between 3.5 and 4.5. Factoring the pH and the isoelectric point into the development of a protein-based product is extremely important for stability. The isoelectric point is the pH where the proteins are neutrally charged. If the beverage is not properly buffered and the addition of acid causes the pH to drop below this point, the proteins will coagulate and fall out of solution. The recommended preservation method for protein-based beverages is heat treatment in the form of hot-fill or UHT.

## Flavorious

Flavor is one of the most important aspects of any consumable. If you don't like what you taste, no matter how good it is for you, you probably won't be buying it again.

When selecting flavors for the no- and low-sugar market, product designers need to have different considerations. "Sweeter flavors are better to use in low-calorie beverages as they give the perception of a sweeter beverage when the full calories are missing," Poskanzer says. "Many of the low- and no-sugar beverages are fruity, and sweet can affect not only the flavor, but the mouth-feel. It is critical to boost and have a strong fruity impact, when sugar isn't present. Many of the flavors used here are common fruits like apple, strawberry, orange, raspberry and lemon. Additionally, we like to utilize fruit combination flavors such as cran raspberry, cran apple, tropical blends, strawberry melon and tangerine grapefruit. Most of the big companies are requesting flavors that are already on the market. They are reformulating beverages to remove sugar and calories, since there is a lot of public pressure from government and consumer advocate groups. However, the entrepreneurial beverage companies will show more innovation, and always look for mainstream and new-age flavors like apple rose, mangosteen or hibiscus for the Hispanic market."

Most flavors for no- and low-sugar beverages are water-soluble. An additional consideration when choosing a flavor, beside the flavor profile, is the sweetening system and the potential aftertaste. Fortunately most flavor companies offer solutions including separate masking flavors to help with this problem. Oilsoluble flavors are also available. These flavors require a more-complex flavor-delivery system, which includes an emulsion, typically gum acacia based, to keep them in solution. They are usually citrus based, owing to the fact their oils are extracted from the skins of oranges, lemons and limes. By the way, you'll know if the emulsion has broken by the ring in the neck of the bottle.

A little bit of acid can help balance the flavor of a beverage, no matter what the sweetening system. Depending on the beverage type—fruity, cola or dairy-based—the acid should complement the flavor. Acids can further act as a mild preservative by lowering the pH. Citric acid is most often used in beverages. Originally it was derived from citrus fruits, though now it is made commercially by other means. Malic acid and tartaric acid are other naturally occurring fruit acids used to modify the flavor of fruit-based beverages by increasing the tartness or sour character. Malic acid works particularly well with apple and cherry flavors, whereas tartaric is a natural in grape drinks. High-acid products, like lemon, might use 3% to 4% citric acid while low acid apple or peach drinks would only use 1% to 2% citric and/or malic acid. Phosphoric acid contributes the distinctive bite to colatype products. Although this is a relatively strong acid, it is used in a dilute form. It also functions as a buffering agent in smoothies. Ascorbic acid is a source of vitamin C as well as an antioxidant.

## A paler shade of white

Without color, most beverages will look just like water. Witness the number of "water" beverages on the shelf—only the ingredient statement knows for sure if they contain sweeteners and flavors. Adding color can draw attention and distinguish it from the competition. And if there's something lacking—namely sugar—a little color can visually enforce the sweet juiciness of a product.

A huge array of color and color systems are available to the product developer. So how do you choose? Color in its simplest form is either "natural" (additives exempt from certification) or "synthetic" (certified). After that it gets complicated. Label claims, target market, heat processing, light exposure, pH, formula ingredients and even the packaging bear consideration when choosing a color or blend. Fruit-juice drinks and dairy beverages typically use fruit, vegetable or other natural extracts, such as grape skin extract, beet powder or annatto. Annatto works particularly well as a yellow color at levels between 1 and 10 milligrams per liter as certain forms



are light- and acidstable. Anthocyanins from grape skin extract give a deep red color below a pH of 3.4, provided that sulphur dioxide is not present, which would negate the color's effect. Beet root and carmine work best in dairy beverages because the pH is higher. According to Sandy Nixon, vice president of science and innovation, D.D. Williamson & Co., Inc., Louisville, KY. "One natural color that is gaining popularity in drinks is elderberry. It is used in teas, juices and drinkable yogurts." Fortunately, colors are used at such a low level that they have very minimal, if any, impact on calories but a huge impact on appeal.

As unlikely as it may seem in a world of bright, eye-catching colors, one of the most popular beverage colors is brown, typically achieved through the use of caramel color. Like any color, caramel color is a complex ingredient. "Caramel in aqueous solutions, like soft drinks, must be chemically- tailored to be compatible with other ingredients," Nixon says. "Soft drinks normally carry negatively-charged particles because of tannins derived from plant material, root, bark, etc. Therefore, a negatively-charged caramel should be selected. An important parameter is the isoelectric point, or the pH at which the colloidal charge is electrically neutral. Soft drinks need a caramel with an isoelectric point below the pH of the beverage to avoid flocculation and precipitation. A Class IV caramel has an isoelectric point between pH 0.5 and 2.0."

Colas, root beer and ginger ales generally use caramel color. According to Nixon, "Cola product developers usually select double-strength caramel for its high color intensity and economy." In addition, she says, "double-strength caramel meets the low-caloric-value requirements of 'diet' or 'light' cola formulations."

## Preservation and pH

Although left until the end of the discussion, a beverage's pH is one of the most important considerations. Choice of ingredients, as well as the beverage's stability and character, depends on the appropriate pH. LowerpH beverages, such as colas and fruitbased products, are typically more microbially stable; but, certain ingredients, such as carmine color, are less stable in an acidic medium. In addition, higher-pH products, such as dairy beverages and waters, cannot rely on acids for extra protection, and their pH may cause issues with certain ingredients; for example, aspartame is less stable at higher pH. The preservation method will depend on the processing facility, packaging, storage and shelf-life. Many soft drinks are cold-filled and use microbial preservatives such as sodium benzoate and potassium sorbate, whereas dairy beverages and some juice products are hot-filled and rely on the heat-processing to destroy the microbes.

The beverage industry is in a constant state of flux. The mature diet drinks are continually being challenged by the infants, both within and outside of the popular beverage producers. Witness Diet Coke making room for Coke Zero and the rebellious Full Throttle Fury Sugar Free. Or Campbell Soup with diet and low-sugar versions of V8 Splash. If ever there was a time to be developing no- and low-sugar beverages, the 21st century is it. The myriad of choices available to the beverage developer are growing every day, so dust off that lab book and get started designing the next thirst-quenching megastar.

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