

FOOD PRODUCT DESIGN®

FRUITFUL BEVERAGES

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By Cindy Hazen, Contributing Editor

We all have our favorite fruit drink. When my cousin was a child, her Italian immigrant grandmother would sit her down at the kitchen table with a handful of cheese curls. A small glass of wine, half diluted with water, was served with the admonition, "No get drunco."

My Anglo grandmother served less-stimulating fare. Juice was straight up, often cranberry or orange. Sometimes, for added excitement, she blended the two.

For all the differences in our grandmothers' kitchens, it seems that our fruit beverages came down to this differentiator—fermented or not.

Today, there are many more choices, from smoothies to fruit-enhanced teas, but like the vintner, the beverage developer needs to know the best ways to develop the perfect finish.

Fruitful beginnings

At the outset, it's critical to think about how the product will be marketed. FDA offers specific guidance for labeling beverages that contain fruit or vegetable juice (Title 21 of the Code of Federal Regulations (CFR), Part 101 Section 30) and requires a percentage juice declaration.

Squeezing the fruit is the most basic means of making fruit juice. In industry this is called not from concentrate juice (NFC). In labeling terms, it is often described as 100% juice. If other ingredients, such as preservatives, are added, this declaration must be accompanied by the name of this ingredient in the phrase "with added _____."

Removing water and concentrating the solids results in juice concentrates. To make a single-strength beverage, these are reconstituted with water to their original density. This is most often measured by Brix, a scale that indicates the percent of sucrose by weight measured by specific gravity. Brix varies by fruit. The CFR provides a table with the minimum Brix required for single-strength (100%) fruit juice. Blueberry has a value of 10 °Brix; cranberry is listed as 7.5 °Brix; pear is 12 °Brix; and pineapple is 12.8 °Brix. Dark sweet cherry is the sweetest of all at 20 °Brix.

Some juices are reconstituted to meet a reference for the anhydrous-citrus-acid percent by weight, such as lemon or lime juice (4.5, according to CFR).

Juice concentrates may also contain other natural flavors (WONF)., but these must be labeled. Other fruit ingredients that may be used in beverages include: clarified juices (clearer choices), purées (contain fruit pulp) and juice essences (recovered from juice prior to concentration).

"Essences are the top-note flavor compounds that are lost after processing," Steve Corson, research chef, Northwest Naturals, Bothell, WA, explains.. "We capture these natural flavor compounds and add them to an alcohol solution for addition to formulas. They are often added back after processing for a more complete, well-rounded flavor profile."

He recommends frozen storage for the best quality and longest shelf life of fruit ingredients. "If the formula has purée or particulates, processing and packaging needs to be watched carefully in order for a consistent product," he cautions.

Besides Brix, it's also important to consider the pH of the fruit ingredient. In addition, "some fruits have higher fat content and can go rancid more quickly," Corson says. "Açaí is notorious for having a high fat content and usually has to be processed in a short window of time, 36 to 48 hours."

One hundred grams of açaí pulp has approximately 48 grams of fat per 100 grams (56.2% oleic acid, 24.1% palmitic acid and 12.5% linoleic acid). In contrast, pears have 0.12 grams of fat, and apples have 0.17 grams.

Fruity options

Corson is seeing increased development of beverage products with some sort of fruit component. "Fruit and fruit juice have a perceived health value that is very strong, and consumers are choosing products consistently with a cleaner ingredient listing," he says. "Whether adding a low level of juice to a beverage, a full fruit or vegetable serving in a beverage or even using fruit juice as a natural sweetener, fruit is a very versatile ingredient and can help a developer create a flavorful, colorful and healthier product."

While all fruits have healthful qualities, some fruits stand out because of their high antioxidant value. ORAC (oxygen radical absorbency capacity) is the standard measure of antioxidant capacity reported as $\mu\text{mol TE}/100\text{ g}$. A May 2010 report, "USDA Database for the Oxygen Radical Absorbance Capacity of Selected Foods, Release 2," attributes a value of 2,359 total ORAC for blueberry juice. Black cherry juice has a value of 2,370. Unsweetened cranberry juice has a value of 1,452.

"Tart cherries are an antioxidant powerhouse, right up there with blueberries and cranberries," says Jeff Manning, chief marketing officer, Cherry Marketing Institute (CMI), Lansing, MI. "Today, there are more than 50 studies on tart cherries, linking the antioxidants in tart cherries to a broad range of benefits—anti-inflammation, heart health, pain relief, exercise recovery and more."

Cherry juice adds a slight tartness to a juice blend. "Tart cherry juice concentrate is a terrific option when a beverage manufacturer wishes to start with a concentrate versus a single-serve juice," says Manning. "Tart cherry juice and concentrate are extremely versatile products. They blend beautifully with the softer juices, such as apple and pear, and do not require special handling or storage. Unlike sweet cherry juice, they add a sweet-tart flavor and a bolder red color. Many manufacturers are experimenting with tart cherry juice, both in single-serve and blended forms."

Proprietary consumer ingredient research commissioned by CMI in March 2011 revealed the greatest potential for cherry juice is in smoothie blends.

Speaking of smoothies, blueberries are a popular option. "In innovative smoothies and dairy drinks, they can add intriguing effects, like blue swirls and patterns, and are essential in almost anything red, white and blue," says Tom Payne, industry consultant, U. S. Highbush Blueberry Council, Folsom, CA. "Blueberry color and texture complement smooth, creamy dairy drinks, add mouthfeel interest, and a sweet-tart blueberry flavor that is a welcome contrast. Blueberries, with their natural high sugar levels, help to remove the sour taste sometimes associated with yogurt, and naturally sweeten the product. Now, drinkable yogurts are utilizing blueberries and blueberry purée to impart a natural taste and blue appeal. Consumers equate blueberries with antioxidant power and, consequently, readily accept them as an ingredient in almost any product."

There are a variety of blueberry formats that work particularly well in beverage formulations, including single-strength juice, which has a Brix of 8.0 to 12.0 and a pH of 2.8 to 3.4.

Blueberry juice concentrate has a Brix range from 45 to 65 and a pH of 2.1 to 2.7.

"For smoothies and other beverages, frozen IQF blueberries are especially suited, as well as abundant," says Payne. "They are available year-round. They provide fresh fruit identity in any formulation where fruit identity is important."

Blueberry powder works well in tea formulations. It is made from fresh or frozen blueberries or purée, drum-dried and ground into powder to specifications. Moisture content is 3% to 5%.

Boosting value

Dairy ingredients can add valuable nutrients like protein and calcium to a beverage, but a little know-how is important when combining with fruit. Fruit drinks are often high-acid. In low-pH applications, many proteins will precipitate. Appearance is less a concern in thick or cloudy beverages like smoothies; however, the protein might yield a slightly grainy mouthfeel. In some applications, certain stabilizers, such as pectin, can also help keep protein stable at a lower pH.

When clarity is important, whey proteins can be valuable ingredients. Soluble across a wide pH range, they work well in high-acid applications such as juices or isotonic beverages. "Whey protein ingredients are highly soluble and have a neutral taste, so they do not compete with intended flavors, making them well-suited for clear, protein-enhanced beverages," says K.J. Burrington, dairy ingredient applications coordinator, Wisconsin Center for Dairy Research, University of Wisconsin, Madison.

Jayesh Chaudhari, MS CNS, senior formulation scientist, Fortitech, Inc., Schenectady, NY, sees widespread use of other fortification ingredients, such as "vitamin C, omega-3 fatty acids, along with calcium and vitamin D3 to aid in its absorption, added fiber in the form of inulin and, of course, a range of antioxidants. We are also receiving condition-specific formulation requests for this category."

For a heart-health claim, Chaudhari suggests fortifying with lutein, lycopene, omega-3 fatty acids, thiamine, sterols and prebiotic fiber. To combat osteoporosis, calcium, vitamin D, magnesium and vitamin K should be incorporated. He recommends adding CLA (conjugated linoleic acid), prebiotic fiber and green-tea extract for weight management. "Each product's ingredient matrix is unique and, as we say here at Fortitech, there is no one-size approach to product formulation," he says. "Our formulations incorporate multiple nutrients in a premix that would otherwise create challenges for the product developer. The desired taste, flavor and color of the finished product, solubility, bioavailability, pH level and safety/toxicity all need to be considered. Nutrient stability is another area that needs to be addressed. Processing conditions, temperature, pH, oxygen, light and moisture are just a few of the factors that can impact stability."

As an example of a potential interaction, Chaudhari offers the formulation of a product that contains both vitamin C (ascorbic acid) and minerals such as ferrous sulfate and copper sulfate. This combination promotes oxidation and can cause discoloration by way of a graying or darkening of the beverage. "For beverages, one must use soluble iron," he says. "Increased solubility increases the potential of interactions."

Off-flavor development may also occur. "Concentration makes a difference here, but B1 can give sulfur notes, and iron and potassium give bitter, metallic aftertastes, for instance. Botanicals can be especially challenging since most give bitter off-notes," Chaudhari says. Using masking agents and/or flavorings can help reduce or eliminate unwanted notes.

"Some additives, such as vitamin blends, can influence the shelf life," says Dennis Kujawski, senior flavorist, International Flavors & Fragrances (IFF), New York. "It's always a good idea for the developer to process and store a product without additional flavors added to determine the amount of change that the base product itself experiences. This can help isolate the 'bad actors.'"

Dinah Diaz, market development manager, beverages and encapsulation, Corn Products/National Starch, Bridgewater, NJ, sees "a move toward botanicals/flowers like hibiscus or chamomille for their health benefits (chamomille for relaxation) and hibiscus tea for anthocyanin." Adding plant extracts that can offer specific health benefits, "such as green tea and aloe, are now making their way into fruit beverages," she says. "As these combinations of fruits, extracts and botanicals make their way mainstream, beverage formulators are challenged to preserve stability and taste preferences."

As consumers look for products with enhanced benefits, they also seek a reduction of less beneficial ingredients, such as sugar. "Reducing sugar means replacing solids and building back mouthfeel. This might also involve non-caloric or low-calorie texturants," says Mary Lynne Shafer, beverage strategy and business development manager, Corn Products/National Starch. "Texture mouthfeel properties become more challenging when customers are looking to reduce the sugar or calorie content in their fruit-based beverages. Naturally, they are expecting to retain the same texture-like quality." The mouthfeel and texture properties of fruit-based beverages tend to be described as pulpy, full-bodied or smooth, she explains.

Many fruit-based beverages, smoothies and nectars that contain pulp, or small bits of fruit, like coconut waters, may require suspension. "When formulators have to cut back on the actual juice components for cost savings, but still want to maintain thick viscosity, they turn to starch or gum products to build back texture and mouthfeel. Pulp replacements are another option," Shafer says.

Fruitful flavor

Think of fruit flavor as a triad. "There are three components to making something taste like a fruit," says Anton Angelich, group vice president, marketing, Virginia Dare, Brooklyn, NY. "There's the sweetness, the acid and the flavor. You need all three in balance. If one is missing it's not going to be the taste of the fruit that you would expect or find in nature."

This ratio, called the Brix/acid ratio, will vary among different fruits and cultivars, and in nature with change with fruit maturity. When the ratio is in perfect balance, based on the target fruit, the flavor will be true.

"Too little sweetness can prevent the fruit flavors from having the impact that you're looking for," says Rob Bent, food technologist, Virginia Dare. "People are interested in naturally low-Brix products, meaning that they want to utilize natural sweeteners like cane sugar, but still end up with fewer calories per serving than traditional options. Sometimes you can add more flavor to compensate for the depression impact that you usually see as you decrease sweetness." Except, that doesn't always work, he explains, "because when you just keep adding more of the same flavor you'll start to get off notes as certain compounds become overloaded. It's also expensive to keep using more and more flavor. You have to optimize the balance between flavor level, sweetness, cost and nutrition, among other factors."

Overuse of flavor can create another unintended consequence. "You may end up getting something that has the right flavor impact but too strong an aroma. It's very hard to separate the two parts—the aroma from the flavor. The compounds that cause one very often also cause the other," Bent says.

To provide an authentic sweetness profile, Stephanie Weil, WILD Flavors, Inc., product manager, marketing, Erlanger, KY, recommends using a combination of sucrose and fructose, the most abundant sugar in fruit. "Fructose also has a stronger up-front sweetness than sucrose and works well in lower-calorie products," she says.

When using non-nutritive sweeteners such as sucralose or stevia, "mixed berry and citrus fruit flavors seem to taste best," Weil says. However, both sucralose and stevia tend to lack the "up-front fruit sweetness" and therefore work better in combination with other sweeteners. She says "a blend of sucralose and acesulfame potassium creates a good overall sweetness balance in zero-calorie products." If a natural claim is to be made, she recommends using stevia with a sweetness modifier or a blend of stevia and fructose.

"We've found that stevia usually works best as a lesser part of a multi-ingredient sweetener system," says Bent. "The technology for producing the high-potency stevia extracts is improving, but the bitter and metallic off-notes that are inherent to stevia are still problematic. We've found that when people are trying to use stevia in beverages, a lot of times their main interest is in making a naturally sweetened claim." For that he suggests moving away from the idea of zero calories and toward a reduced-calorie application. "When you're looking for beverages that are reduced-calorie you can incorporate other natural sweeteners, like cane sugar, agave nectar and more neutral-tasting fruit juices, like white grape and pear," he says. "You can then optimize the amount of sweetness you get from stevia while minimizing its off notes. If they really want zero calories, then the best option is to combine stevia and erythritol, but erythritol is limited by U.S. law to 3.5% in beverages. In terms of using erythritol and stevia while limiting off notes, our advice is to keep that sort of formulation to low and moderate sweetness beverages for now."

If sweetness is the second leg of a three-legged stool, then acid is second. "Fruit-flavored products can be enhanced by ingredients and chemicals that naturally occur in the raw fruit," says Weil. "Acids play a critical role in fruit-flavored products as they provide the bite or tartness desired when eating a fresh fruit." Different types of acids are found in different types of fruits. Apples and strawberries are naturally high in malic acids; grapes and cranberries are high in tartaric acids; and citrus fruits are high in citric acids. "Using the proper acid or combination of acids for a particular fruit is very important," says Roni Eckert, research scientist, Wixon, Inc., St. Francis, WI. She offers the example of tannic and malic acids to promote pomegranate flavor.

Flavorists at Virginia Dare have found that, in certain applications, a subtle level of floral flavors or floral notes enhances fruit flavors. "The floral flavor isn't distinguishable on its own, but it adds to the complexity of the fruit

flavor," says Bent. "One combination that we've found to work pretty well is raspberry and rose. It's not a strong rose flavor." He recommends using a light touch with a floral flavor because high levels can cause imbalance in the overall taste perception.

Fruit flavors can also benefit from the addition of a very low level of vanilla. "If flavors come out too narrow, sharp or high-ended, when you add a touch of vanilla it really rounds out the flavor and can make it more complex," says Bent.

The beverage base will affect the flavor impact and character. "For example, a strawberry flavor added to a juice-based beverage will deliver quite a different profile from the same strawberry flavor added to a milk-based beverage," says Kujawski. "In the milk-based beverage, lipophilic components in the flavor will be held more in the milk fat and the flavor release will be changed. The flavor would have to be optimized for the milk base."

Flavor perception will differ if a beverage is served warm or cold. The presence of alcohol will also impact flavor. "When you have alcoholic, dairy, high-viscosity or low-Brix bases, they're going to require higher concentrations of flavor, relative to a reference 10 Brix soft-drink base, to achieve the same sensory impact," says Bent. "It takes more flavor in certain beverages to get the same sensory impact."

And there's a difference between flavoring carbonated and still fruit beverages. "We were using strawberry flavors in a carbonated base," says Bent. "Acetic acid is a common ingredient in strawberry flavors. The still version of this beverage tasted great. In the carbonated version, the carbonation made the acetic acid much more prominent." Changing the strawberry flavor to one containing less acetic acid compensated for the change in base.

Processing beverages and the fruit juices or concentrates that are used in them can often change the flavor of the finished product. "Fresh and juicy notes are usually decreased, resulting in a cooked character," says Kujawski. "Therefore, flavor is often added to give the product a brighter and fresher profile."

When working with functional ingredients, it's important to add compatible flavors. A delicate flavor, such as watermelon, might be overwhelmed.

"A lot of the functional compounds have a bitter nature to them," says Bent. "One way that we can help deal with that is to use fruits that naturally are expected to have some degree of bitterness or astringency. When you have functional compounds that are astringent, you don't want to use a flavor where you would expect it to be juicy and mouthwatering, but when you put something like cranberry in there, the astringency of the ingredients is framed in a way that the consumer is not surprised. It's acceptable."

Taste synergy is important when combining fruit and tea. Tea polyphenols and tannins can be astringent, so they work best with flavors that are synergistic. "Apple doesn't work well with tea," notes Angelich. "They're not as compatible. When you add two things together you may end up with something that's neither. Take grapefruit. When you add it to tea, it doesn't taste like grapefruit anymore and you're not going to be satisfied. If you are looking for a certain amount of definitive tea taste, the grapefruit negates the tea. If you end up with something that's neither tea or grapefruit, you're probably not going to buy a lot more of it. Sometimes in the creation of product you end up with something that is a great combination and creates something totally new, and that is great--something like peach melba, which is peach and raspberry. Strawberry kiwi is a great combination, or strawberry banana."

Tea has a number of qualities that can go well with fruit at low levels, but not at higher levels. "Strong earthy or astringent attributes might work poorly with a flavor, but at lower levels those qualities could pair nicely with the fruit," says Bent. "Sometimes you need to tone down the tea or up the fruit flavor to strike a balance that works for both ingredients."

Similarly, when combining fruit flavors, consider contrast. Many fruit flavors contain some compounds in common, so it's important to search out complementary differences between flavors to create exciting fusions. "You want to work with flavors that contrast nicely against each other so that each flavor can shine on its own," Bent says. "If you don't, a lot of times you'll end up with a combined flavor that's muddled. If they're too similar, neither fruit can stand out as a distinct flavor. One classic example that's been around that illustrates this point is kiwi strawberry. Those contrast really nicely. Strawberry offers a base that has sweet, rich, red berry tones. Kiwi, on the other hand, has lots of top notes. It's very punchy and almost floral, so they play nicely off of each other. Each one can stand out on its own."

Equally important is the idea of temporal flavor development. Flavors are perceived at different times. "It may take longer for some to come up, and others might come up very fast on the front end. If you pay attention to the temporal properties of the different flavors that you're using, you can get a nice combination where you'll have a drink and it will be one flavor, and then another flavor, and then another flavor, as opposed to all of them coming up at the same time and, again, it ends up with a muddled taste instead of distinct fruit flavors," Bent says.

This concept is often seen when people comment on wine. Bent says wine and fruit juices are more alike than not. "Fruit flavors, when combined appropriately, can produce the same sort of dynamic taste experience, even in a soft beverage," he says.

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