Carotenoids for Color

By Rachel Adams, Assistant Editor

The color of a food or beverage plays a large role in the success of a product because color not only makes a product more attractive, but it can affect how consumers perceive its taste. Bottom line: getting color right is crucial. And carotenoid-based colors can go a long way to making that happen.

Consumers are looking for products made with more natural ingredients, and colors are no exception. If anything, colors are near the top of consumers' hit list when it comes to ingredients of concern. The food additives market in the United States will reach $5.5 billion by 2018, with natural colors driving the growth, according to the "Food Additives: The U.S. Market" report by Packaged Facts, Rockville, MD. Carotenoids used as colorants in foods and beverages are yellow, orange and red pigments synthesized by plants. Often, consumers perceive these colors as "natural" based solely on the fact they can wrap their minds around their fruit, vegetable or spice origins. In addition, some carotenoids are recognized for added health benefits, increasing their appeal, especially among health-conscious consumers.

Although synthetic dyes have long been preferred by food product designers, application know-how and improvements in technology are not only putting carotenoid colorants on the map, but making them a destination in product development.

Natural under the scope

What consumers consider natural and what FDA considers natural don't always match up, especially when it comes to colors. FDA does not define colors as "natural" or "artificial;" rather, colors are exempt from certification or are certified in accordance with the federal Food, Drug & Cosmetic Act (FD&C). Those exempt from certification are listed in Title 21 *Code of Federal Regulations* Part 73, and tend to shine a little brighter in the "natural" light compared to synthetic dyes toting an FD&C-certified number on the label. Exempt color additives are not required to be declared by name on labels but may be declared simply as "colorings" or "color added." Regardless, even naturally derived exempt colors are only considered "natural" by FDA if a product receives its color from the food itself. For example, lycopene extracted from tomatoes and added to a tomato sauce is deemed natural, whereas lycopene added to yogurt is not.

While this clears the waters for food and beverage manufacturers, consumers aren't likely to peruse the *Code of Federal Regulations* (*CFR*) when deciding which fruit juice to purchase. Instead, they turn to the ingredients statement, where they look for simple ingredients, often lacking complex chemical-sounding names. In the color world, certain carotenoids, along with ingredients that contain them, generally fit the bill. Fortunately for food product designers, many are found on FDA's exempt list.

More than color

Of the 600 carotenoids from natural sources that have been characterized, those used to add color in foods and beverages include beta-carotene, lycopene, bixin and norbixin (found in annatto), apocarotenal, zeaxanthin (saffron), capsanthin and capsorubin (paprika) and canthaxanthin.

A number of these offer health benefits that resonate well within the growing number of health-conscious consumers. Beta-carotene is considered the most nutritionally active carotenoid, and offers provitamin-A activity. Vitamin A is essential for normal growth and development, immune system function and vision (*The FASEB Journal* 1989; 3:8, 1927-1932). Other provitamin-A carotenoids include apocarotenal (although it has 50% less provitamin activity than beta-carotene) and canthaxanthin.

Beta-carotene is recognized as a main dietary source of vitamin A and can be used for both its nutrient and color attributes. Under section 201(t)(1) of the Federal Food, Drug and Cosmetic Act and Title 21 *CFR* 70.3, a substance used to impart color may constitute use as a color additive and as a food additive or GRAS substance. Beta-carotene is one such substance—approved for use as a color additive (21 *CFR* 73.95) and affirmed as GRAS for use as a nutrient (21 *CFR* 184.1245).

Beverages and beyond

Because all carotenoids fall somewhere in the line of yellow, red or orange, there are several options to create the ideal color in that range—whether formulating dairy products, beverages, baked goods or other products. However, not all carotenoids perform the same in different formulations, and can be affected during processing or by packaging. So knowing which product to use in which application is key to keeping product development smooth and successful.

According to Jennifer Brown, global applications scientist, DDW, Louisville, KY, beta-carotene is the most common carotenoid colorant, and is used most often in beverages, specifically fruit juice drinks. However, its yellow color, which Brown describes as “egg yellow,” can benefit a variety of applications, including cheese products, margarine, butters, dairy products and non-dairy creamers. In beverages, beta-carotene is also seen in some flavored waters, carbonates and energy drinks.

In formulations, Brown says beta-carotene is “very acid stable” and “has good light stability, so it’s not going to fade on the shelf.” However, using beta-carotene to color beverages can present some challenges. For example, if the emulsion isn’t stable, the finished product can create a yellow ring lining the cap of the beverage packaging. While this is “a potential challenge,” according to Campbell Barnum, vice president, branding & market development DDW, it’s “not a challenge every time. It depends on the quality of the emulsion; when the emulsion is not stable, then that’s an issue.”

Beta-carotene is available in water-dispersible and oil-soluble versions. The oil-soluble versions—which can be used for a yellow tone in products like microwavable popcorn, margarine and other oil-based products—typically contain 22% and 30% beta-carotene, whereas the water-dispersible versions common in the marketplace have 1% and 10%. Beta-carotene is one carotenoid that, in addition to being naturally derived, can be created synthetically, a form that some call “nature identical.” “Nature-identical is a little more economical, so it has a larger market,” Barnum says. “But we’re seeing some growth in the naturally derived beta-carotene. Both look the same on the label, but customers prefer to pay that premium for the naturally derived kind.”

Apocarotenal—a carotenoid that occurs naturally in citrus fruits and some vegetables, such as spinach—produces a yellow/orange color, and is often used in cheese products, Brown says. “Color

depends on the concentration—you can do yellow to a darker color, like a darker, warm red." In fact, Barnum says apocarotenal will achieve a hue closer to red than annatto or beta-carotene.

During formulation, apocarotenal is stable across the pH range of about 2 to 8, and has good light and heat stability. Its powder form also works well in extrusions.

When used in beverages, apocarotenal and beta-carotene "typically produce a fair amount of turbidity," says Marlena Hidlay, associate marketing manager, DSM Nutritional Products, Parsippany, NJ. This is also seen with canthaxanthin, which produces a bright red color.

Annatto is another commonly used carotenoid that can range in hue from yellow to orange/red and is commonly used to produce a strong orange color. "One of the neat things about annatto is, in lower concentration, it appears yellow; as you increase that concentration, it's more orange," Brown says. "Predominately, it's an orange color."

Unlike beta-carotene, annatto is not stable in lower pH ranges, making it less ideal for use in beverage applications. "Limitations occur when you start to get it down into the pH ranges of below 4," she says. "At 3.5 it starts to precipitate out." However, her company produces an acid-stable annatto that can go to lower pH ranges between 3.8 to 3.5.

Annatto exhibits "excellent heat stability," Brown says, making it very stable in baked goods. Annatto also has good light stability, although it is susceptible to oxidation, which can cause color to fade. Other applications include seasoning blends, breaders and cheese products, including cheese seasonings and natural cheese products. In powder form, "annatto will give that speckly look, which works well for cheese," Barnum says.

Unlike other carotenoids, annatto can be both water soluble (norbixin) and oil soluble (bixin), Brown says, which is important for use in fried applications. "This is why it is useful in batters and breaders. If you use the water-soluble type to add color to your batter and breader, it's not going to color the oil."

Lycopene

Lycopene can create a range of red hues. In dairy products, such as yogurt, and salad dressings, lycopene will produce "strawberry-pink" hues, Brown says. However, during heating—in bakery and beverage applications, for example—lycopene tends to create a red-orange color. Therefore, "lycopene can replace carmine in dairy products, but not in baking due to heat stability," Brown says.

According to Brown, lycopene is stable across the pH range of about 2 to 8, although acid in the application will enhance the color to provide a brighter hue. Lycopene is also recognized by consumers on the label, and is often associated with various health benefits. Although it has no provitamin-A activity, lycopene does exhibit a physical quenching rate constant with singlet oxygen almost twice as high as that of betacarotene, and has been shown to protect against a broad range of epithelial cancers (*Crit Rev Biotechnol* 2000; 20:4, 293-334).

Spice origins

Paprika and saffron colorants derived from spice origins contain carotenoids. Paprika carotenoid colorants—manufactured from the dried and ground sweet pepper pods of *Capsicum annum*—include capsanthin and capsorubin, and will create an orange color. Paprika can also be solvent-extracted to produce paprika oleoresin, a purified form of the coloring compounds. Paprika colorants are used frequently in salad dressings and in savory applications like spices and seasonings, Brown says, adding that they also blend well with turmeric and annatto to give different shades of yellow-orange used frequently in popcorn.

To avoid adding unwanted flavors, all forms of paprika colorants—whether powder, oleoresin or liquid—need to be deodorized because at high levels paprika will impart a "pepper flavor, but not heat," Brown says. Paprika is also susceptible to oxidation, which can be minimized through the use of proper packaging. For example, the clear plastic that goes on the outside of a popcorn bag is actually designed to help with the stability of the oil-soluble colors, such as annatto and paprika, which can oxidize in fat, Brown says.

Saffron—cultivated from the stigma of the flower *Crocus cartwrightianus*—contains a variety of carotenoids found in other plant sources, such as zeaxanthin, lycopene, alpha- and beta-carotenes, and will produce yellow to orange hues. Like paprika, saffron will impart flavor and color. While it is used as a color additive, it's less cost-efficient than alternative colorants, such as annatto, limiting its usage.

When it comes to foods and beverages, "consumers are becoming more aware of what they're consuming," Hidlay says, and it couldn't be more true. While "natural" colors were once considered less than ideal, new technologies and innovations, along with a little application know-how, are making the switch to those favorable colors, like carotenoid colorants, a breeze.