FOOD PRODUCT DESIGN

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Perusing the Food Color Palette

By Sharon Gerdes, Contributing Editor

For most foods, color might be the last item on the ingredient legend, but the first consideration in the consumer's mind. Color can create new line extensions and invigorate mature brands. Unexpected bursts of "artificial" colors might boost sales, but label-friendly "natural" colors could prove to have the most-enduring appeal, especially in today's market where natural ingredients seem to increasingly draw a premium.

Colorful categories

As far back as 1,500 B.C., natural colors started to find their way into our culture, often as dyes for cosmetics and fabrics. Various ancient civilizations used annatto to paint their bodies and color their food. Egyptians, Mayans and Incans are all believed to have used carmine or similar dyes derived from female insects to produce magenta dyes for their clothes and lips. When Columbus attempted to discover a faster route to the East Indies, one of the spices he sought was turmeric, a spice used over the centuries to color food, enhance taste and treat various ailments. Manufacturers still use these pigments today to brighten modern foods.

The industrial revolution brought changes. By the early 1900s, almost 80 synthetic dyes were found in food, often with little testing or regard for safety. So in 1907, the U.S. government established the first list of seven colors certified as safe and suitable for use in foods. That list of Food, Drug and Cosmetic (FD&C) colors—outlined in the Food, Drug and Cosmetic Act—has changed over the years, but interestingly, the United States is currently back to seven certified FD&C colors: Blue 1, Blue 2, Green 3, Red 3, Red 40, Yellow 5 and Yellow 6.

FDA defines colors as either certified (commonly known as "artificial"), as noted in Title 21 of the Code of Federal Regulations (CFR), Part 70, Section 3f, or exempt from certification (typically called "natural"), such as those in 21 CFR, Pt. 70.3g. Besides the seven certified colors, FDA lists 31 colorants exempt from certification for use in foods. The latter group includes the ancient favorites of carmine, annatto and turmeric, plus newer additions, such as beet powder, red-cabbage extract and grape skin. From a regulatory perspective, "natural colors" do not exist. FDA does not consider that any color added to food is natural unless the color is natural to the food product itself—raspberry juice for a raspberry product, for example. However, consumers have definite and varied opinions on what they perceive as "natural."

A natural trend

The past 10 to 15 years have seen a distinct move toward naturals, especially within flavors and colors. "The move is particularly pronounced in the United Kingdom, Scandinavia and the northern

part of continental Europe. Many consumers associate natural products with superior quality. A good, natural-looking color in a food or beverage will signal high quality, while a washed out or artificially bright product can give the opposite impression. Also, colors derived from well-known sources, such as beetroot, grapes, cabbage and paprika, are more readily recognized and accepted by consumers," according to Luc Ganivet, marketing manager, Chr. Hansen, Montpellier, France.

Certain segments of the market are demanding more natural colors. "This shift seems to be driven by consumers who want more natural and/or organic foods, rather than the rejection of widely used colors, such as the FD&C colors. The use of natural colors is most prevalent in beverages that portray a healthy image, yogurt products and in egg-replacement products. In certain food categories, such as cheese, the use of natural colors has been preferred for many years," notes John Foley, laboratory manager for BASF in North America, Florham Park, NJ.

Other forces driving the demand for natural colors in the United States include the standards of certain food companies and grocery chains that do not allow artificial colors in their products. Examples are Austin, TX-based Whole Foods and Boulder, CO-based Wild Oats grocery chains, which only sell foods with natural colors, explains Stefan Hake, general manager of GNT USA, Inc., Tarrytown, NY.

For many years, natural colors couldn't match their synthetic counterparts, especially with regard to brightness and stability. However, developments in formulation and processing technology have now considerably changed that shortcoming. "The most-important development within process technology has been encapsulation," says Ganivet. "This has brought forward a number of advantages for natural colors, such as improved stability, increased brightness and reduced use of certain additives—such as emulsifiers—and reduced color migration."

While the bakery industry has traditionally used a lot of certified colors, at least one manufacturer has developed natural-color blends for use in certified-organic bakeries. "Natural-color blends can produce vibrant yellow, red, orange, blue and green icing colors, and can be mixed to produce the entire visual spectrum of color. This is an important breakthrough because, before now, bakeries had to use artificial colors to achieve the entire visual spectrum of color," notes Stephen Lauro, technical services manager, colorMaker Inc., Anaheim, CA. These natural-color blends are light, heat and pH stable in bakery applications, such as sweet breads, cupcakes, cookies and muffins. They are also completely soluble in icings, unlike traditional natural colors, which tend to separate or color icings unevenly.

However, food manufacturers have to pay a premium for natural colors. "Unfortunately, there is really no comparison in terms of cost of natural versus synthetic colors—natural colors are simply more expensive. Despite that, we have seen an increase in popularity in recent years as the trend toward natural foods continues and manufacturers strive to have more consumer-friendly labeling on their products. Obviously, natural colors are not for every manufacturer or application, but there are certain companies at the forefront of the functional-food trend for whom natural colors make sense," notes Ellen Schutt, vice-president, marketing, RFI Ingredients, Blauvelt, NY.

Colorful fruits and veggies

Rather than using exempt colors, another approach is to incorporate foods that have coloring properties. These include extracts from fruits, vegetables and plants that have been processed by physical methods to concentrate and stabilize the colors. "This approach has more impact in Europe, where these foods with coloring properties are not considered food additives, and do not require an 'E' number. Again, under U.S. regulations, there are no truly 'natural' colors, but we believe the consumer is smart enough to know the difference," notes Hake.

The technology to produce superior foods with coloring properties involves controlling the entire process vertically from the time the seed is put in the ground. "The first step is to know where to grow the plants to produce optimal color. The next step is to develop careful physical processes to stabilize and preserve the colors. Finally, the product must be consistent," explains Hake. The result is a colorant that would be safe for a consumer to take with a spoon and eat. This certainly would not be recommended with some "natural" colors or with the FD&C colors.

A healthy bonus

The general health trend will continue to be significant in the years to come. "Many different nutrients are today applied in functional foods, and more will be added over the coming years," says Ganivet. "Some of these are natural color pigments, which have only recently been recognized for their possible health effects. The trend to launch 100%-natural-flavored and -colored applications is stronger and stronger. It is a means to create differentiation and attract consumers, who are, as well, more and more interested in healthier and more-natural food."

Several pigments currently recognized for their nutritional contributions include the carotenoids and anthocyanins. "Natural carotenoids include carotenes, lutein and lycopene and have been recognized as antioxidants that are linked to the prevention of degenerative diseases. Epidemiological evidence of the nutritional benefits of fruit and vegetables points to a range of carotenoids rather than a single carotenoid providing these benefits. Anthocyanins, or polyphenols, from grape skin are known to lower the risk of cardiovascular disease in areas with a large wine consumption," comments Ganivet. This effect contributes to the "French Paradox."

Blueberries are another source of anthocyanins. "The Produce for Better Health Foundation's 'Five a Day the Color Way' lists blueberries in the blue/ purple category of fruits and vegetables that provide varying amounts of health-promoting phytochemicals, such as anthocyanins and phenolics, currently being studied for their antioxidant and anti-aging benefits. Specifically, they note that boosting the level of blue/purple foods in a low-fat diet helps lower the risk of some cancers and may promote urinary-tract health, memory function and healthy aging," according to Thomas Payne, industry specialist for the U.S. Highbush Blueberry Council, San Francisco.

Food technologists need to understand and appreciate that color should be one of the first considerations when formulating a "natural" product, explains Lauro. More marketing managers

recognize the importance of going to market with a product that delivers a consistent "good-for-you" message from the principal display panel to the nutritional statement to the ingredient list. This developing trend drives continued growth in the use of natural colors.

Warm and sunny

Several natural colors produce a warm range of yellow to reddish-orange color hues. These include beta-carotene, ß-apo-8'-carotenal, annatto, paprika and turmeric. The last two ingredients are also spices, and work well in cheese, seasonings, batters and breadings. Suppliers offer water-soluble, deflavored versions of turmeric for delicately flavored foods, such as ice cream and yogurt.

Beta-carotene formulations are designed to meet specific needs for different segments of the food industry. "When formulating foods with high fat content, such as margarine, popcorn oil or muffin mixes, the use of a 22% heat-stabilized beta-carotene or 30% product in oil is preferred for ease of use. Beta-carotene in cold-water-dispersible (CWD) powder or emulsion forms is suitable for confections, egg substitutes, soups and beverages. These products will lend a color that ranges from yellow to an orange-red, depending on the formulation type chosen and processing conditions. The CWD-type products can also be used in dry products that require long shelf life, such as cookie or cake mixes. Combinations of beta-carotene and apo-carotenal are often used to produce an orange color in processed cheese," notes Foley.

A few formulation tips will ensure good stability for these natural pigments. "The primary cause of carotene and lycopene degradation is oxygen, and, to a lesser extent, heat and light. In a dry mix, such as a cake mix, it's best to limit possible interactions with iron. When adding beta-carotene and lycopene to beverages and yogurts, the addition of ascorbic acid or sodium ascorbate is recommended. When used in food systems with significant oil content, the use of heat-stabilized products or the addition of antioxidants, such as tocopherols, will help improve stability," adds Foley.

Few processed foods contain lycopene other than those with tomato-based ingredients, such as tomato paste, juice or powder. "The nature of lycopene is that it is a powerful antioxidant and produces an orange-to-red color. Lycopene is currently GRAS as a nutrient. A baked food product fortified with lycopene can take on an orange color. When used in beverages, lycopene can add a color that ranges from red to red-pink. The coloration effect of lycopene may not be noticeable in foods that have their own deep color if a small amount, typically 1 mg or less of lycopene per serving, is used," notes Foley. FDA is presently considering a petition for the use of lycopene in foods as a color additive exempt from certification.

Tickle me pink

To produce the pinker reds to purples, food formulators can turn to beet colors, cochineal and carmine colors, as well as anthocyanins. The anthocyanin group includes colors derived from elderberry, black carrots, red cabbage, aronia, grape skin and blends of these ingredients. These colors produce pink and red shades in the acid range around pH 3, and are more blue or purple at a neutral pH of 7.

Anthocyanins find their way into beverages, fruit preps, confections, frozen desserts and sauces. "In general, anthocyanin-based colors are the least stable, particularly in beverage applications. Among the anthocyanin-based colors, acylated anthocyanins are most stable; these include red radish and purple carrot. RFI has a particular red-radish color that does well competing with carmine, which is not applicable for kosher applications (due to its insect derivation), and red 40," comments Schutt.

It's always helpful to work with a color supplier that understands various food systems. "Beverages may sit in a window and be exposed to various types of light, as opposed to ice cream, which is stored in a cold, dark container. Beet juice works well in ice cream, but it is not good in beverages. For beverage applications, red cabbage, purple carrot and black carrot provide greater light stability," comments Hake.

The combination of water, light and pH tends to destabilize colors in beverages. One way to meet this challenge is with a special blend of natural colors. Ganivet notes that the ColorFruit range was developed to target stability in low-pH beverages containing ascorbic acid. This new natural color is a blend of anthocyanins to produce four shades, from red to violet and purple. It also provides very good heat stability.

Another example that might need a color blend would be a fruit-on-the-bottom yogurt requiring a strawberry shade, which should be more orange-red. "In a yogurt system, the pH of the yogurt is 4.5 to 5.0, and the pH of the fruit prep sitting on the bottom of the yogurt is 3.0. For a strawberry shade, the fruit prep may contain a natural color from anthocyanins, such as purple carrot. The challenge comes when the consumer mixes the yogurt and the fruit prep. This leads to a pH increase causing the anthocyanins to shift color from red to blue. To offset this effect and produce a more strawberrylike color, a manufacturer might use a blend which also combines carotenes from pumpkin," explains Hake. Working with a supplier that has more ingredients and expertise in these areas offers distinct advantages.

The food industry is constantly sourcing new natural colors. colorMaker is working closely with a company in India extracting anthocyanins from a subtropical fruit. "The fruit is grown and consumed primarily for its ability to suppress the appetite, and is marketed as a 'natural-weight-loss' ingredient. The skin and pulp of the fruit, however, are highly pigmented and thus an excellent source of anthocyanins. We are hopeful the anthocyanins extracted from this fruit will be of the same quality as those extracted from purple carrot, but will be far less expensive," notes Lauro.

Singing the blues

According to a study by the Eiseman Center for Color Information and Training, Seattle, color is very influential in food and everywhere else. Their results state that "in our studies, blue remains the favorite color. Consumers have a love affair with blue. It's the No. 1 color in Europe, Asia and North America." Scientific research suggests that anthocyanins in strong-colored berries, like blueberries, might have a role in preventing heart disease. A three-year European study is currently investigating the functional properties of anthocyanins and anthocyanin-rich food ingredients and their influence on heart disease.

For food processors, blueberries are a natural. They can be used whole, diced, fresh or dried, freeze-dried as purée concentrate or juice. According to Payne, some of the more interesting examples of blueberry use include: blueberry salsas and sauces paired with nontraditional seasonings, like tarragon and cider vinegar; blueberry barbecue sauce; and a traditional candy with a modern blueberry twist, Blueberry Wagashi from Japan.

Another source of natural blue shade is Blue Carantho, produced by Overseal Natural Ingredients, Derbyshire, England. This natural, stable blue uses a particular type of vegetable extract that, through formulation and processing technology, can provide a sky-blue hue in certain applications, such as confection making. "The color has global legislative approval and is suitable for halal and kosher requirements. Blue Carantho has been used in many types of confectionery and bakery products, especially those marketed toward children. Particular applications include instant desserts, panned confectionery, compressed tablets, bakery icings, and cakes and biscuits," notes Schutt.

Interesting color twists

The regulations for both natural and certified colors vary from country to country. In their quest to find a natural green shade, U.S. food formulators have not had as many options as their European counterparts. Sodium copper chlorophyllin has been widely used in Europe as a natural green color. However, in the United States this heat-, light- and pH-stable color has only been allowed in citrus beverages. Lauro believes that a petition might be filed shortly expanding its use to other foods.

The overseas market uses less artificial colors than the U.S. market. "In Europe, there is a restriction on the use of Red 3. Our company recently developed a line of gel colors without Red 3. Red 3 is a typical component of brown, pink and Christmas-red colors. For Europe, the company has used carmine or carmoicine in place of Red 3. Red 40 can also be used, but that gives more of a fire-engine-red," adds Pat Tygh, director of R&D for Chefmaster, Santa Ana, CA.

If a project requires a black color, the choices are carbon, certain caramel colors or a mixture of certified colors. In 2003, Chr. Hansen developed a new natural black color. As with several other natural options, this color is allowed in other countries, but not currently in the United States.

Although some might not think of white as a color, titanium dioxide adds opacity to foods, and is often used in combination with other colors to achieve a soft, pastel shade. Titanium dioxide is a relative newcomer to the food industry, and the world produces nearly 9 billion pounds of it per year. Titanium dioxide is not water soluble, but rather must be dispersed in foods. In the United States, the maximum usage level for titanium dioxide in foods is 1%.

Earth tones

Caramel colors create a wide range of shades, from yellow to red to brown to almost black, depending on the hue and strength. Caramel color shows up in unexpected places, such as lemonade. Generally, caramel colors are earth tones rather than bright colors. Caramel colors have

been available since people started cooking, but there are a few new developments, notes David Tuescher, technical director of Sethness Products Company, Clinton, IA. The company recently developed a new Class I caramel color with a mild taste and good solubility in salty systems. This new color can be used in soy sauces and drinks without creating bitter notes.

The International Technical Caramel Association has defined four classes of caramel color that depend on the food-grade reactants used to manufacture the color. Class II and IV caramel colors contain sulfites, so food manufacturers need to be aware of color concentrations and declare sulfites on the label if such content exceeds 10 ppm in the finished product. "When using caramel color, food formulators should be aware of the ionic charge of the color and their food system. Class I is slightly negative to neutral, Class II is strongly negative, Class III is positive and Class IV is strongly negative. Generally, food formulators would not want to use a caramel color with a negative charge in a system with positive ions, such as calcium, because the color may precipitate, or a clear product can become hazy," according to Tuescher.

There is no exact definition of "natural." However, many food-industry clients generally consider Class I caramel colors natural. This product can appear as "caramel color" or "artificial color" on product labels. Tuescher notes that his company has recently been producing more GMO-free caramel color by sourcing different carbohydrates. Generally, dextrose makes a superior caramel product with greater shelf life and stability, but sucrose and alternative sources of dextrose can become the starting point for a GMO-free caramel color.

When developing a meat and sauce, a company might need to add one color to the meat and then a different color to the sauce to achieve the desired final effect. Food manufacturers sometimes can experiment to achieve a unique result, such as when one manufacturer combined a positively charged and negatively charged caramel color, which produced a gel. This resulted in a thick soy sauce, which the company perceived as very positive.

Caramel colors work well in various meat applications. They can enhance yellow in chicken, and red or brown in meats. They can be used to imprint images on meat, including lot numbers and expiration dates. Most grill marks on processed meats are actually caramel color. They impart a quality perception to the consumer. Finally, caramel colors can enhance and extend various flavors. Typical applications would include cocoa replacement, cinnamon replacement and coffee extenders.

The certified seven

The other class of colors defined by FDA is certified colors. Each batch of certified colors must meet specifications for purity outlined in 21 CFR, Pt. 80.10 to 80.39. With seven certified colors, designers can achieve quite a range of food colors using blends of these basic colors. For greater accuracy and consistency, food manufacturers can purchase custom blends from their color supplier. Certified colors are available as either water-soluble dyes or insoluble lakes precipitated on an aluminum hydroxide substrate. The liquid dyes can be dissolved in water, glycerin or propylene glycol, often with added preservatives.

To meet different formula and processing needs, certified colors are also available in a variety of different forms, including powders, liquids, granules and plating dyes, including dust-free types, like the new FD&C Blue 1 product from Sensient Food Colors, St. Louis. "This exciting innovation significantly reduces handling issues, such as cross-contamination and employee morale. Like with our other granular products, Dustmaster Blue 1 dissolves easily, and is suitable for systems that have a hydration step during processing," notes Penny Martin, manager of technical service for North America. However, granular dyes cannot be used in dry mix due to striation issues.

In general, certified colors are more stable than natural colors. "However, both sunlight and fluorescent light will cause many colors to fade," notes Tygh. Natural colors also have less stability to heat than certified colors. Within the FD&C colors, Red 3 is the least stable, especially to fluorescent lights. One solution for the baker is to increase the amount of color to compensate for the fading. If an icing would normally use 0.5% color, try increasing it to 1%, suggests Tygh. However, caution should be used because too much color can make a product appear dull or dark.

"The other issue with certified colors is moisture migration, especially in baked goods that would be frozen, then thawed. The certified colors will move with the movement of water, resulting in streaking. The solution to this issue is to use lakes instead of dyes, especially in frozen items that will be defrosted," adds Tygh.

Lakes can be produced from pure dyes using 1% to 45% dye to form aluminum salts of the FD&C colors. Lakes, water-insoluble forms of the FD&C dyes, work better in specific applications for a number of reasons, notes Harry Meggos, vice president of technical service, Sensient Food Colors North America, Kingston, Ontario. "One example where food-product developers would choose a lake over a dye is in oil-based systems, such as compound coatings, icings and cookie fillings. Lakes are also used in dry-mix systems, such as a compressed candy or vitamins. The lake system will exhibit color in the dry mix by dispersing, unlike a dye, which would require water before the shade is developed. Another suitable opportunity for lakes instead of dyes is in chewing gum. Water-insoluble lakes are selected by the food-product developers for chewing gums, because the lake will exhibit color and stay trapped in the gum matrix, rather than leaching into the saliva as would happen with a dye." In some cases, lakes are used in place of dyes as they can exhibit better stability.

When lakes are used in a fat-based product, such as chocolate or a compound coating, the lake would typically be dispersed into a high-quality oil. However, when lakes are used for panning of candies or pills, the lake would be dispersed in a sugar-water solution. The coloring power of lakes is a direct result of an even distribution of small, colored particles, sometimes as small as 0.5 microns. Lakes are not recommended for use outside of the optimal pH range of 3.0 to 7.0 as they can delake, or break from their substrate, thus defeating their functionality.

Special coloring systems

Many challenging food ingredients exist, and color is one of them. "It's not as straightforward as one may initially think—it's generally not as simple as squeezing a few drops of liquid food coloring from a

little tube into your cookie icing at Christmastime. It's interesting to note that in 1997, a food-product-developer survey published in a food magazine listed color as the second-most-challenging ingredient to work with. Compound the various color chemistries, applications and ingredient interactions with international color regulations, and you really have a challenge," explains Martin.

Coating systems are another innovative color delivery option. These include complete, pre-hydrated polymer film coatings that are designed for preparation just before use. "Color-coating systems are appropriate for sugar and sugar-free panned chocolates, candies and gums," adds Martin. "Sugar- or aqueous-based liquid dispersions of colors are commonly used to provide the color coating. Uncolored coating systems are also appropriate for panned confections—to provide gloss or a seal."

colorMaker has developed innovative, natural, color-blend emulsions that can be plated onto sugars or salts. "Typically, water-soluble natural colors dissolve sugars and salts, leaving behind a rock-solid fusion that has to be removed from the mixing vessel with hammer and chisel," notes Lauro. "Their natural, color-blend emulsions plate evenly and completely onto sugars and salts, creating colorful, topical applications for baked goods and snack foods alike. These natural, color-blend emulsions also work in personal-care products, such as lotions, creams and moisturizers—and in our personal favorite, white chocolate!"

Nonflashing blends ensure that when the consumer reconstitutes a dry mix, they see only one brown color, rather than a "flash" of red, yellow and blue spots. However, sometimes food manufacturers want to see separate colors. "Sensient Colors also offers a line of colored film particulates called Spectra Flecks™, which are available in soluble, flavored and insoluble formats. These small film particulates add a splash of color to many items, including snack foods, confections and icings," notes Martin.

Going wild with color

While natural might rule with adults, children tend to go for bright and unexpected colors. "Children are always fascinated with bold colors and with color changes, such as in a jawbreaker that changes colors as it dissolves in the mouth," notes Tygh. Color changes to the tongue hold a certain fascination for this audience.

Children also favor colors that relate to movie and cartoon personalities. "Barney purple is still a winner, as is Big Bird yellow, Kermit-the-Frog green and Elmo red. Interestingly, color appears to trump 'traditional' flavor profiles among young children. One customer markets brightly colored soy-based hot dogs to children with flavors such as strawberry, cherry and orange. The kids love it. Young children see no reason for a hot dog to have a savory meat flavor only. If it's a hot dog, and it's red, it can taste sweet like cherries," comments Lauro.

Color innovation can also add excitement to adult foods. "A quick search on the Mintel database will yield a host of innovatively colored foods introduced, such as colored margarine, colored ketchup-type condiments, colored pancake syrup, colored cheese products, and the list goes on. Colors for

new food promotions are often linked to movie themes—Shrek green is a recent example. Colored line extensions for food products add excitement and new interest. It's an easy way to invigorate a brand," according to Martin.

The bottom line is that food products must look appealing at both the time of purchase and consumption. Color can range from brightly colored, fruit-flavored cereals, to very subtly colored vanilla ice cream. Just remember that in today's food market, more and more consumers are looking not only at the food color, but also at the food label. The right color might make a product a hit—certified and bold or natural and wholesome. Either way, food should sparkle with color.

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