BY **KAREN NACHAY**

A new color

Consumer demand for more 'natural' foods and beverages has sent ingredient developers back to nature to unearth a broadening spectrum of naturally derived food and beverage coloring options.

Remember in the movie *The Wizard of Oz* when Dorothy crossed the threshold from her sepia-toned world into the Technicolor Land of Oz? You just knew that the world in which she landed was captivating and that something exciting was about to happen.

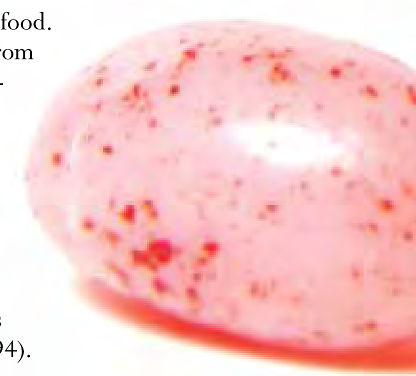
Yes, that is the power of color. It can elicit excitement, and it also plays important roles in how we perceive what we see.

Color is one of the most important attributes of foods and beverages. It is the first thing we notice about a food product, and it can invite us or dissuade us from trying the product. It also affects our perception of how fresh food is. As it is often said, we eat with our eyes first.

Sometimes, though, the color of processed food and beverage products is less than brilliant. Processing degrades color, and light, air, moisture, temperature, and storage can cause color to diminish and lose vibrancy over time. So manufacturers turn to the spectrum of color ingredients to add color or enhance what is already there, or to create consistency across a product line. Some colors added to food products can help protect vitamins and flavors from degradation. And added colors provide whimsy to food, particularly seasonal sweets and snacks and foods marketed for children.

An ingredient used to impart color to foods is called a color additive, and the Food and Drug Administration defines it as "a dye, pigment, or other substance made by a process of synthesis or similar artifice, or extracted, isolated, or otherwise derived, with or without intermediate or final change of identity, from a vegetable, animal, mineral, or other source and that, when added or applied to a food…is capable (alone or through reaction with another substance) of imparting a color thereto. Food ingredients such as cherries, green or red peppers, chocolate, and orange juice, which contribute their own natural color when mixed with other foods, are not regarded as color additives, but where a food substance such as beet juice is deliberately used as a color, as in pink lemonade, it is a color additive" (CFR, 2006a). Color additives are not to be used deceptively as in masking a spoiled, damaged, or inferior product (CFR, 2002b).

In the European Union, colorings "are substances which add or restore colour in a food, and include natural constituents of foodstuffs and natural sources which are normally not consumed as foodstuffs as such and not normally used as characteristic ingredients of food. Preparations obtained from foodstuffs and other natural source materials obtained by physical and/or chemical extraction resulting in a selective extraction of the pigments relative to the nutritive or aromatic constituents are colours" (OJEC, 1994).



palette emerges

Color additives are naturally derived or synthetically produced, and over the years, some controversy has arisen about the safety of synthetically produced color additives. One noted controversy that has been around for more than 40 years is that synthetic color additives can adversely affect behavior in children, particularly those diagnosed with Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD). While research conducted over the years has not found conclusive evidence of this, and scientists explain that the additives undergo rigorous safety and quality testing, some consumers are not convinced and avoid foods that contain these color additives, if at all possible. Other consumers are trending toward a more "natural" lifestyle in which they are purchasing products made without synthetic or artificial ingredients, products that are eco-conscious, and so on. »»

***Brightly colored confections** are among the products suitable for coloring with naturally derived color additives.*

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A new color palette emerges

***These four samples show the color range** achieved with using naturally derived lycopene and luein in solution.*
Photo courtesy of LycoRed

Much of this has gained a wider, more-mainstream consumer appeal recently. As a result, food and ingredient manufacturers are taking notice and have begun to produce many products that meet these consumers' needs. In fact, Mintel noted in its Global New Products Database that in 2008, "natural" claims appeared on 23%—nearly one in four—food and drink product launches (Mintel, 2009).

This article is not an indictment of certain color additives, nor is it advocating the use of only naturally derived color additives. Both synthetic and naturally derived colorings serve their own functional purposes. Rather, this article will briefly review some of the controversy, particularly a recent study that prompted the EU to issue a labeling requirement on foods that contain certain synthetic color additives. More importantly, though, the article will discuss some recent color ingredient developments to help manufacturers meet labeling requirements and to formulate products that meet consumer demands.

Regulations 101

The Federal Food, Drug, and Cosmetic Act governs how color additives are approved, how they should be used in foods and beverages, and how they should be labeled on packaging in the United States. These color additives are either "certified" or "exempt from certification." Both types are subjected to various safety and toxicology tests, but those classified as certified, which are synthetically produced from petroleum-based sources, must be submitted by the manufacturer for batch certification by FDA (FDA, 2007). This process involves FDA analyzing new batches of color additives to ensure that they meet established specifications. When a batch is deemed acceptable for use in foods, drugs, and cosmetics, its common name is changed to the following naming convention: the acronym FD&C, a color, and a number, e.g., FD&C Yellow No. 5. The number of colorings on the list has changed over the years; currently, there are nine, seven of which are approved for use in foods in the United States. The other two are used to color casings or surfaces of frankfurters and sausages (Orange B) and the skins of oranges not used for processing (Citrus Red No. 2).

Color additives exempt from certification, meaning that they do not undergo batch certification, are derived from plant, animal, or mineral sources. These include annatto extract, caramel, beta-carotene, grape skin extract, turmeric, paprika oleoresin, and others. A few of the exempt color additives, like beta-carotene, are also made synthetically, and those in the industry often refer to these as nature-identical colorings.

To describe food products and ingredients, the food industry, media, and consumers use the terms "artificial" and "natural" rather loosely in some cases. Calling exempt color additives naturally derived may be acceptable in the industry, but they cannot officially be called natural.

Remember, FDA does not have a legal definition for the term natural. FDA considers certified, or FD&C, color additives as artificial, and the resulting food products colored with them as artificially colored, but it may surprise some people to know that the agency considers exempt color additives as artificial (CFR, 2006b). The rationale is that if a color additive, regardless of its derivation, is not inherent to the food product, that product has been colored artificially. An example of an exception is when a pigment isolated from, say elderberries, is used to color elderberry ice cream, says Jennifer Guild, Global Food Science & Regulatory Manager, D.D. Williamson.

Certified color additives are listed on ingredient declarations by their certified name, e.g., FD&C Red No. 40, but it is not necessary to include "FD&C" or "No." on the declaration (CFR, 2006b). Exempt color additives may be listed as "artificial color," "artificial color added," or "color added" or a term that indicates a coloring was used, as well as "colored with X" or "X color," with X being the name of the color additive (CFR, 2006b).

The EU designates food additives, including food colorings, with an "E" followed by a number. Food additives that bear this code have undergone and passed various safety tests and are

Yogurt-based dressings *owe their colors to fruit and vegetable concentrates.*
Photo courtesy of GNT

deemed safe for use in foods. Much like food additives approved for use by FDA, the approval of these food additives comes under review when new scientific data are produced. In the EU, when the term "artificial color additive" is used, it refers to what are recognized in the U.S. as "color additives subject to certification," "certified color additives," "certified color additives," "FD&C color additives," or "synthetic," according to Guild.

"It is essential that we learn to appreciate the language of color additives and how this language can change, depending on the region in which one is working," she adds. "In the U.S., it is important that the terms 'artificial color' and 'synthetic color' are not used interchangeably. It is important that we do not add to the confusion surrounding naturally derived, but technically 'artificial,' color additives in the U.S. by confusing these additives with 'synthetic' additives."

Research Leads to Action

Debate about the effects of certain synthetic food colorings on children's behavior began in 1975 after the release of the book, *Why Your Child Is Hyperactive*, an oft-cited reference in the argument for eliminating the use of synthetic food colorings. Authored by Ben Feingold, a pediatric allergist who worked at the Kaiser Permanente Medical Center in California, the book explains his research findings about how synthetic colorings, as well as other synthetic food additives, can cause hyperactivity and learning disabilities in children. The book also includes information about the Feingold program, a diet that recommends avoiding the following synthetic additives: colors, flavors, sweeteners, and preservatives.

For almost two decades before publishing his book, Feingold and other researchers conducted research on the subject, but interest in the topic rose sharply almost immediately after the book was published, and it continues to this day. Despite research that has not found a definitive link between synthetic food colorings and hyperactivity, a grassroots following of Feingold's work and the diet he espoused grew throughout the years.

Recently, though, one particular study has caught the attention of some food safety advocates. A study published in September 2007 that showed a link between dietary intake of synthetic food colorings and additives and hyperactivity in children led the Food Standards Agency (FSA) in April 2008 to call for a voluntary ban by manufacturers on the use of six synthetic colorings in food products sold in the UK by the end of 2009. FSA also said that the colorings should be removed from food sold in the EU but did not suggest a deadline. The colorings are sunset yellow (E110), quinoline yellow (E104), carmoisine (E122), allura red (E129), tartrazine (E102), and ponceau 4R (E124); they are used in soft drinks, ice cream, cakes, and sweets.

McCann et al. (2007) conducted a randomized, double-blinded, placebo-controlled, crossover study in which they gave 153 3-year-olds and 144 8–9-year-olds a drink that contained either sodium benzoate and one of two mixes (mix A: 20 mg of synthetic food colorings or mix B: 30 mg of synthetic food colorings) or a placebo. The researchers chose the food colorings because they are found in foods that children eat. They are also the colorings now included under FSA's voluntary ban. Children who were taking medication for ADHD did not participate in the study, commonly referred to as the Southampton study.

The results showed that hyperactivity significantly increased in the 3-year-olds who consumed mix A + sodium benzoate as well as in the 8–9-year-olds who consumed mix A + sodium benzoate and mix B + sodium benzoate. The researchers stated that they received funding from FSA but reported no conflict of interest.

The European Food Safety Authority, a risk assessor that produces scientific advice to support European policies and the EU, pointed out what it called "limitations" with the Southampton study, which included "the inability to pinpoint which additives may have been responsible for the effects observed in the children given that mixtures and not individual additives were tested" (EFSA, 2008). Indeed, the study did examine the effects on hyperactivity levels produced by mixtures of synthetic color additives consumed in conjunction with sodium benzoate rather than only individual color additives. But that did not stop some government agencies

Carrots contain carotenoids and anthocyanins*, pigments that give the vegetable its color. These pigments are extracted and used as naturally derived colorings for many food and beverage products.* Photo by Stephen Ausmus, courtesy of USDA's Agricultural Research Service

and consumer advocacy groups from placing restrictions or calling for bans on the use of synthetic colorings.

Shortly after the Southampton study was published online early in September 2007, FSA advised concerned parents to reduce or eliminate from their children's diets foods that contain any of the six colorings (FSA, 2007). And in July 2008, the European Parliament stated that foods containing the six colorings must be labeled with the warning, "consumption may have an adverse effect on activity and attention in children." It has given manufacturers 18 months from that time to comply with the new regulation. Those who drafted the regulation did take into account other studies, as well (EPHA, 2008).

The consumer advocacy group Center for Science in the Public Interest (CSPI) in June 2008 filed a petition calling on FDA to ban the use of FD&C Blue No. 1, FD&C Blue No. 2, FD&C Green No. 3, Orange B, FD&C Red No. 3, FD&C Red No. 40, FD&C Yellow No. 5, and FD&C Yellow No. 6. CSPI realized that banning these color additives would take time so it wants FDA in the interim to require foods that contain these color additives to carry a notice such as, "Warning: The artificial coloring in this food causes hyperactivity and behavioral problems in some children" (CSPI, 2008).

In the meantime, FSA is working with manufacturers to help them meet the standards. Some manufacturers report that they have already removed these colorings or are developing alternatives. FSA in March 2009 published a list of products that have never contained the six color additives or have been reformulated so they no longer do. The list, which FSA will continually update as manufacturers submit information, includes *Worldfoods* products (Asian Asset Group); *Green Bay* products (Green Bay); *Heinz*, *Weight Watchers from Heinz*, *HP* (Heinz), and others.

Ingredient suppliers are providing expertise and advice to manufacturers as they reformulate products to meet the standards. Sensient Colors Inc., which produces both synthetic and naturally derived colorings, is one such company that is informing manufacturers about the timeliness associated with the move to naturally derived colors. According to the Color Group of Sensient Technologies Corp., a number of the naturally derived colorings come from crops that need to be planted and harvested in certain areas of the world, and this requires much longer lead times to produce than synthetic colorings.

Innovations Meet Demand

The debate about synthetic color additives and hyperactivity aside, consumers are demanding more "natural" products for many reasons. And who better to help them meet the demand than product developers and ingredient suppliers, as well as industry players like grocery stores and large mega-marts. Popular retailers like Marks & Spencer and Tesco in Europe and Trader Joe's and Whole Foods Market in the U.S. carry entire lines of private-label, store-branded products formulated without synthetic color additives. Although it is not an easy task, these and other companies have succeeded in providing products to consumers who want to reduce or eliminate their intake of synthetic additives. In a company press release from 2008, David Gregory, Director of Technology at Marks & Spencer, commented that there were challenges faced in reformulating some of the more than

900 products over the course of three years. “It’s only once you start to remove colorings, you realize how much we eat with our eyes, coupled with an expectation for some products to look a certain way.”

A challenge in formulating with color additives—or for that matter, any food ingredient—is finding additives that withstand the rigors of processing, time spent in storage, and the pH environment of the finished product, as well as show stability under environmental conditions such as light, temperature, and moisture. For years, the industry standard was to use synthetic colorings. They are often more vibrant as well as more heat, light, and pH stable than naturally derived colorings, and smaller quantities of them are required to achieve the desired results. Oftentimes, it is the application that drives the use of particular color additives.

“Because high heat and pressure [extrusion] processes challenge the stability of natural colorings, less rigorous processes are more compatible,” says Campbell Barnum, Global Vice President of Branding & Market Development at D.D. Williamson.

Throughout the years, though, ingredient suppliers developed naturally derived colorings from a variety of sources that have improved stability under certain conditions in certain applications. For example, to counter oxidation of annatto pigments, antioxidants can be added to the color formulation or food application. Anthocyanins isolated from fruits and vegetables are sensitive to pH changes, heat, and light, so they are acylated (adding an acyl group to a compound) to produce anthocyanins that are more stable (Emerton, 2008). Radish anthocyanins further acylated showed promise as a coloring alternative to FD&C Red No. 40 and FD&C Red No. 3 in maraschino cherries (Giusti and Wrolstad, 2008). These and other technological developments have allowed for the successful use of naturally derived color additives in many applications, and these additives are proving to be quite effective.

“Dairy and beverages are the largest sectors, though ingredient technology and consumer demand are driving more natural coloring applications in confectionery, desserts, dressings, sauces, and pet foods,” says Barnum. “Wider application of natural coloring has necessitated more blends of two or three colorings to achieve custom hue and stability solutions.”

The important thing to note here is that you must understand the nature of the application, how the colorings interact with other ingredients in the formula, and the order in which all of the ingredients are added, says Stefan Hake, CEO of GNT. His company manufactures the *Exberry®* line of fruit and vegetable concentrates for use as color additives. To produce its concentrates, the company uses physical extraction and water rather than chemical solvents or additives, which are often used to extract pigments. While the *Exberry* line has been available for several years, the

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The blue coloring *in this frosting is made with anthocyanins extracted from red cabbage.* Photo courtesy of D.D. Williamson

company continues to add to it, and the line includes concentrates from not only carrots, grapes, and red cabbage but from hibiscus fruits, pumpkins, and aronia berries.

FDA states that fruit and vegetable juices, as concentrates, can be used as color additives, and that the label must list the fruit or vegetable juice or juice concentrate and indicate it was used for color (CFR, 2002a, 2002c). In the EU, fruits and vegetable juices and concentrates are considered "foodstuffs" and not color additives (OJEC, 1994).

Hake adds that consumers feel comfortable when they see fruit and vegetable juices and concentrates used as colorings listed on the ingredients declaration, and he believes that the inclusion of these types of colorings is gaining popularity.

Sensient offers a line of naturally derived colorings—*Fusion*™ *Precise Natural Color Systems*—that includes colorings from many sources, including fruit and vegetable concentrates. The Color Group of Sensient Technologies Corp. gives examples of how manufacturers can label these types of colorings: "colored with fruit/vegetable juice" or "black carrot juice concentrate (for color)." Used in a variety of applications, including beverages, dairy, confectionery, and processed foods, the line of colorings is available in shades from yellow to red, which the company says are the more popular food colors (as are pink and purple shades) and often easier to achieve with naturally derived colorings.

Concentrating juices is one way to color foods with naturally derived colorings. Another way is to use the actual pigments that give fruits and vegetables their color. Carotenoids such as lycopene in tomatoes and beta-carotene in carrots produce a range of colors from yellow to red, and anthocyanins such as grape skin extract give fruits and vegetables their red, blue, and purple colors.

Tomatoes are rich in lycopene, and LycoRed offers a coloring derived from lycopene isolated from tomatoes. The coloring, *Tomat-O-Red*, is offered in a ready-to-use powder or liquid formulation and as an oleoresin. Light and oxygen affect lycopene on its own. To counter this, the company has coated lycopene crystals in its ready-to-use formulations to increase stability to light and oxygen and reduce the occurrence of color change during processing. The oleoresin formulation is standardized to 8% lycopene and is used to color foods after it is emulsified or solubilized to form a transparent micro-emulsion or an opaque emulsion. The company's lycopene offerings work well in confectionery applications such as panned sweets where other naturally derived colorings are unable to provide a stable red color, says Andrew Kendrick, International Technical Development Manager of LycoRed.

Lycopene is approved for use as a food coloring in the U.S. and EU. FDA recognizes lycopene as "exempt from certification," and carries a declaration of "lycopene," says Kendrick. The EU also approves lycopene for use as a food coloring "but it is only the natural form which is extracted from tomatoes that can be used," he explains. It must be declared as "E160d" or "lycopene."

Carotenoids are oil soluble, and D.D. Williamson's technology has led to the development of water-dispersible, naturally derived ones. In January 2009, the company, which manufactures a wide variety of synthetic and naturally derived color additives, introduced one such ingredient, a water-soluble beta-carotene that is said to offer quick dispersion, less cloudiness in solution, and reduced sedimentation, ringing, and cap/bottle staining. It is particularly useful in beverages with a pH of 3.0–7.0.

Oftentimes, the very nature of the application limits which color additives can be used. As the pH of an application changes from acidic to basic, the molecular structure of anthocyanins change from red to purple to blue, making the use of naturally derived anthocyanins to impart a blue color in a product with a lower pH a challenge. At a pH of 5.5, the anthocyanins impart a weak purple hue. D.D. Williamson and its strategic partner colorMaker, in 2008, developed a naturally derived, water-soluble, shelf-stable blue coloring for use in applications with a pH of 5.5–8.0. The coloring, made from anthocyanins extracted from red cabbage, is best used in frozen dairy products, colored sugar, bakery frosting, toppings, dry mixes, candies, and other non-acidic confectionery products. The companies have also experimented with adding naturally derived yellow coloring to this blue coloring to create naturally derived green colorings.

A Bug's Life

Fruits and vegetables and the components found in them are used to produce many of the naturally derived colorings available. However, one coloring in particular has an interesting origin.

The cochineal insect lives a relatively uneventful life on cacti growing in parts of Central and South America. But this little bug contains a pigment that when extracted produces the brilliant crimson color additives called cochineal extract and carmine. Produced from the ground bodies of the female beetle using water or solvent extraction (cochineal extract) and further processing with aluminum and calcium ions (carmine), the compounds are used to color products like yogurt, confections, and beverages.

For centuries, people have used cochineal extract as a dye for textiles and coloring for foods. Today, the additives are approved for use in foods and beverages by various governments. In the EU, the additives must be listed as "food color" followed by E120 or cochineal, carminic acid, or carmines in the appropriate local language (OJEC, 1994). Currently, in the U.S., cochineal extract and carmine are exempt from certification and therefore can be listed as "artificial color," "artificial color added," or "color added." However, this will change in January 2011, when manufacturers will be required to declare the two additives on ingredient lists as "cochineal extract" and "carmine" (Federal Register, 2009). FDA made the change in response to reports citing severe allergic reactions some people had after consuming foods that contained the additives, as well as in response to a 1998 petition filed by CSPI. Carmine is especially useful in a variety of applications as it has good stability to heat, light, and oxidation, "but some consumers question its insect source," says Barnum.

Discovering New Alternatives

Current research conducted on different sources—from fruits and vegetables to plants and marine creatures—shows promise in developing new naturally derived colorings or enhancing ones already approved for use. Pan et al. (2008) showed that red pigments extracted from the seeds of *Osmanthus fragrans*, otherwise known as the sweet, or tea, olive plant, were soluble in alkaline, acidic waters, and hydrophilic organic solvents. The pigment showed stability in a temperature range of 25–100°C as well as in solutions with sodium sulfite, sodium chloride, amino acids, organic acids, sugar, starch, or metal ions. It did not perform well in high pH environments.

Another study conducted on plants includes one that examined betacyanin pigments in *Opuntia stricta*, or prickly pear, fruit juice. Obón et al. (2009) obtained the coloring by spray-drying the juice. They added the coloring to yogurt and a soft drink and found that the red-purple color was consistent after one month of refrigeration at 4°C. Castellar et al. (2008) isolated the red pigment betanin from prickly pear fruit and juice though fermentation and subsequent concentration.

Dharmaraj et al. (2009) found that *Streptomyces* strain (AQBWWS1) isolated from a marine sponge and fermented under

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Beverages are popular products in which formulators include naturally derived colorings. *Red shades are most in demand, but other shades are growing in popularity.* Photo courtesy of D.D. Williamson

fluorescent white light produced pigments from carotenoids that could be used as food-grade pigments. The researchers say that the next step is to determine if the process can be scaled up to mass produce the pigments.

"The success of any pigment produced by fermentation depends upon its acceptability in the market, regulatory approval, and the size of the capital investment required in bringing the product to market," report the researchers.

While studying the antioxidant properties of a pigment found in another marine creature, a microalgae, Pouvreau et al. (2008) learned that the pigment, called marennine, had good light and heat stability and may show promise as a naturally derived, blue-green coloring.

Trošt et al. (2008), in comparing the degradation rates of blueberry anthocyanins, found that cyanidin glucoside was the most stable. They say that the findings hold promise in developing more-stable anthocyanin-based colorings.

Shikov et al. (2008) showed that the addition of rose petal extracts rich in natural copigments slowed the thermal degradation of strawberry anthocyanins, which improved overall color stability.

This research as well as the innovations mentioned earlier in this article represent just a fraction of the work being done to develop vibrant, effective, and stable naturally derived color additives. As more consumers demand "natural" foods, and legislation restricts the use of synthetic color additives, ingredient developers will invest more in research and development to capitalize on the trend. **FT**

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