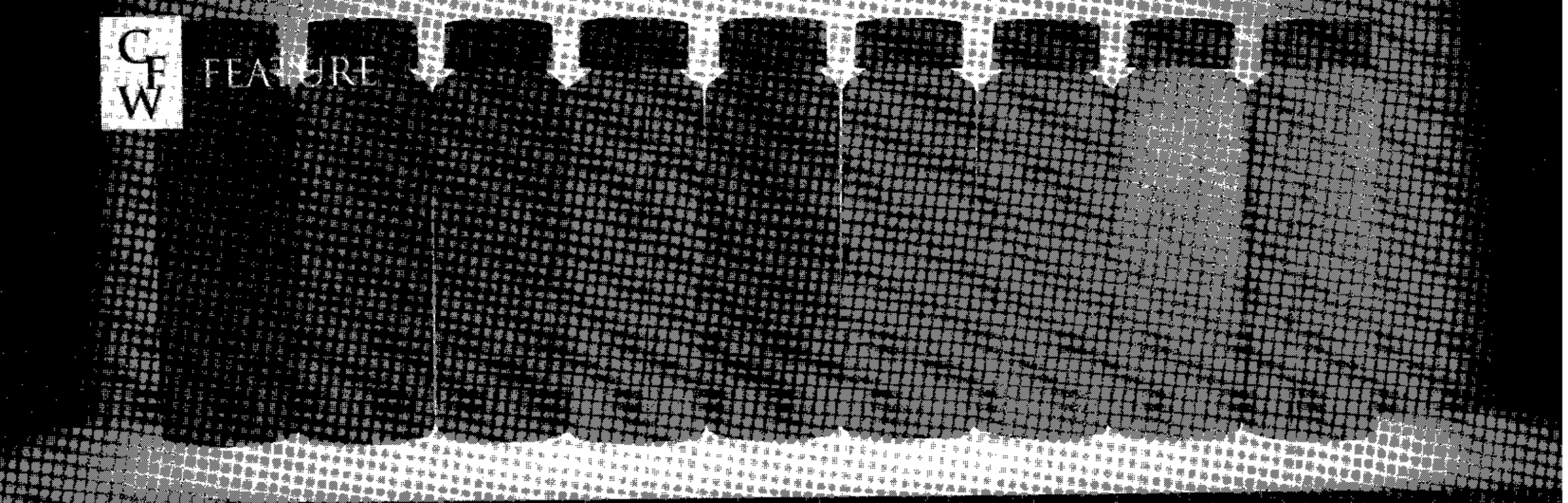

Colorants for Cereal and Snack Foods

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Color in cereal and snack food products is critical to attracting and keeping new customers. It is the first thing they see when looking at a product and often what first catches their eye. The proper shade can help distinguish a product from its competitors and help build brand loyalty. The wrong shade can communicate a message that a product is unsavory or unhealthy.

Natural colorants, such as carmine, henna, iron oxides, and saffron, have been used in cosmetics and textiles since 5000 B.C. and have been added to foods since 1500 B.C. Synthetic colors, such as FD&C Red No. 40 and FD&C Yellow No. 5, were first derived from aniline, a coal-tar derivative, in 1856 and commercialized shortly thereafter. Although synthetic food colorants dominated the market in the United States throughout most of the twentieth century, in recent years the greatest growth has been in natural colorants. As with other food products and additives, consumers are increasingly demanding colorants that are natural, kosher, GMO-free, and organic or organic-compliant. Furthermore, food processors are increasingly requiring ingredients that can be used worldwide, which is much more likely to be the case for natural colorants.

U.S. Regulatory Framework

Approved Colorants. Color additives have been controlled federally since at least 1906. The way in which colorants are regulated was overhauled in 1960 with the passage of the Color Additive amendments to the Federal Food, Drug and Cosmetic Act of 1938. These amendments basically provide for a positive list of colorants that can be changed only by the Food and Drug Administration (FDA) after a formal rule-making procedure. Unlike flavors and other additives, there are no provisions in the law for company, industry, or trade-group approval of colorants based on either previously sanctioned use or GRAS affirmation by an outside group of experts.

Most consumers who care to make a distinction break colorants down into two groups: natural and artificial. In fact, colorants are more appropriately divided into three categories: natural (e.g., beet powder, grape juice, saffron), nature-identical synthetic (e.g., most β-carotene, canthaxanthin), and synthetic (e.g., FD&C Red No. 40, FD&C Yellow No. 5). However, under the current regulatory scheme, colorants are divided into two categories: certified, which includes those synthetic colors that must be tested batch-by-batch by the FDA to ensure conformity with purity specifications, and exempt, which includes those natural and nature-identical synthetic colorants that are exempt from FDA batch testing. Certified colorants that are permitted for use in foods are listed in Title 21 of the Code of Federal Regulations (CFR) Section 74 (Table I).

Lakes of these certified colorants are also provisionally permitted under 21 CFR Section 82, except for the lake of FD&C Red No. 40, which is permanently listed together with the FD&C Red No. 40 dye at 21 CFR Section 74.340, and the lake of FD&C Red No. 3, which was delisted a few years ago. There are a few additional synthetic colorants permitted for use in food contact applications, such as coloring citrus peels, that have not been included in Table I.

The natural and nature-identical exempt colorants approved for use in human foods in the United States are listed in 21 CFR Section 73, reproduced in part in Table II. Listed colorants may be used subject to the restrictions contained within each regulation, which may include either usage level limits or application restrictions. For example, grape skin extract is only approved for use in beverages.

There are many other natural and synthetic colorants that are used in other parts of the world but that are not approved for use in foods in the United States. However, under Section 801 of the Federal Food, Drug and Cosmetics Act, as amended several years ago, these colorants may be imported for use in foods for export to countries where these colorants are permitted, subject to certain record keeping, notification, and use requirements. Table III provides a nonexhaustive list of these colorants.

Although a number of the colorants listed in Table III offer stability, shade, cost, or other advantages over many currently approved colorants, the high cost and burden of filing a colorant petition is beyond the means of most colorant producers. Therefore, most new product development has been geared toward identifying new sources that fit into existing regulations, such as fruit or vegetable juice colors.

Labeling. The regulation for the labeling of colorants in finished foods and beverages is found at 21 CFR Section 101.22(k). Under this regulation, certified colorants must be labeled by their name in the applicable regulations. The "FD&C" prefix is no longer required, but the term "lake" must be included if applicable (e.g., Red 40, Yellow 5 Lake). Exempt colorants may be labeled as "color added," "colored with ___," or "___ color," with the blank filled in with the name of the color additive in the applicable regulation (e.g., fruit juice color). There is a provision in 21 CFR Section 101.22(k)(3) that exempts butter, cheese, and ice cream from labeling of colorants

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unless it is required by the specific colorant approval regulation (e.g., FD&C Yellow No. 5). In practice, most dairy product manufacturers declare the colorants used in these applications. Incidental additives in color preparations lacking functional effects, including processing aids, are frequently exempt from inclusion on the finished product label under 21 CFR Section 101.100(a)(3).

In contrast to its policy on flavors, the FDA position, as delineated in the preamble to the Nutritional Labeling and Education Act, is that the term "natural" may not be used to refer to any "color additives, regardless of source." Thus, it is always improper to label a product as containing "natural color." Some companies have attempted to maximize the marketing benefits of using natural colorants by making such declarations as "colors derived from natural sources."

Table I. Certified colors approved for use in human foods under 21 CFR Section 74

21 CFR Section	FDA Name	Common Name	Shade	Heat Stability	Light Stability
74.101	FD&C Blue No. 1 dye	Brilliant blue FCFt	Blue	Excellent	Good
74.102	FD&C Blue No. 2 dye	Indigo carmine	Blue	Good	Poor
74.203	FD&C Green No. 3 dye	Fast green FCF	Green	Good	Good
74.303	FD&C Red No. 3 dye	Erythrosine	Red	Excellent	Poor
74.340	FD&C Red No. 40 dye and lake	Allura red	Red	Fair	Excellent
74.705	FD&C Yellow No. 5 dye	Tartrazine	Yellow	Good	Excellent
74.706	FD&C Yellow No. 6 dye	Sunset yellow FCF	Orange	Fair	Good

Table II. Selected exempt colors approved for use in human foods under 21 CFR Section 73

21 CFR Section	FDA Name	Primary Shades	Heat Stability	Light Stability
73.30	Annatto extract	Yellow to orange	Good	Fair
73.40	Beet powder	Pink to red	Poor	Poor
73.75	Canthaxanthin	Orangish red	Good	Fair to good
73.85	Caramel	Tan-brown	Excellent	Excellent
73.90	β-Apo-8′-carotenal	Yellow	Good	Fair to good
73.95	β-Carotene	Yellow to orange	Fair to good	Fair to good
73.100	Cochineal extract	Orange or red	Excellent	Excellent
73.100	Carmine	Pink to red	Excellent	Excellent
73.125	Sodium copper chlorophyllin (powdered citrus beverages only)	Green	Good	Good
73.140	Toasted partially defatted cooked cottonseed flour	Pale yellow	ND[a]	ND
73.169	Grape color extract (foods only)	Purplish red	Fair to good	Fair to good
73.170	Grape skin extract (beverages only)	Purplish red	Fair to good	Fair to good
73.250	Fruit juice	Orangish red to purplish red, purple, blue	Fair to good	Fair to good
73.260	Vegetable juice	Orangish red to purplish red, purple, blue	Fair to excellent	Fair to excellent
73.300	Carrot oil	Yellow	Good	Fair to good
73.340	Paprika	Orange	Good	Fair to good
73.345	Paprika oleoresin	Peach to orange	Good	Fair to good
73.450	Riboflavin	Yellow	Good	Fair to good
73.500	Saffron	Yellow to orange	Excellent	Excellent
73.575	Titanium dioxide	White	Excellent	Excellent
73.600	Turmeric	Yellow	Excellent	Poor to fair
73.615	Turmeric oleoresin	Yellow	Excellent	Poor to fair

[a] Not determined.

Table III. Partial list of colors that are not approved for use in human foods in the United States but that may be used for export products

Common Names	Primary Shades
Alkannet	Red
Amaranth (synthetic)	Red
Astaxanthin	Peach to reddish orange
Brown HT (synthetic)	Brown
Cacao	Brown
Carmoisine (synthetic)	Red
Chlorophyll	Green
Enzyme-modified gardenia	Blue, green, red or black
Lac	Orange or red
Lycopene	Red
Monascus	Yellow, orange or red
Onion	Brown
Ponceau 4R (synthetic)	Red
Perilla	Red
Quinoline (synthetic)	Yellow
Safflower or carthamus	Yellow or red
Sandalwood	Red
Sepia	Black
Spirulina	Blue

Cereal and Snack Food Applications

Certified colorants are widely used in the cereal and snack food industries. Until recently, however, the use of natural colorants has been limited primarily to annatto, beet, β-carotene, carmine, paprika, and turmeric because of the relatively high pH of the end products. Although these colorants are widely used in cereal and snack food applications, each has its own shortcomings. Beet is inexpensive, but it is unstable and tends to brown quickly in the presence of heat or light. Annatto, turmeric, and paprika frequently lack adequate light stability. β-Carotene can be difficult to disperse and is also susceptible to UV-fading. Carmine, while extremely heat and light stable, is unsuitable for some applications due to the origin of the material and its questionable kosher status. In the past few years, however, breakthroughs have been made that allow for greater use of natural colorants in cereal and snack food applications.

First, new application technology has been developed to improve the heat and light stability of annatto, beet, β-carotene, and paprika with various antioxidants. Second, there is a new yellow, soluble saffron colorant on the market that provides excellent heat and light stability in neutral pH and oil-based applications, with minimal flavor impact and reasonable cost-in-use. Third, in recent years natural blues and greens have been developed that help complete the palette of natural shades. Fourth, progress has been made in the development of stable, kosher red colorants suitable for use in products with a pH ranging from 5 to 7. Finally, a new generation of acylated anthocyanins from black carrot, elderberry, grape skin extract, purple sweet potato, low-odor red cabbage, and red radish, has been developed that is more stable at higher pH levels and can be used in low water activity applications to produce purple, blue, green, and red shades in many cereal and snack food applications.

Using Natural Colorants

Choosing Natural Colorants. Certified colorants are typically used in cost-driven applications or applications for which it is assumed that consumers are not concerned about the synthetic origin of the raw materials, such as most candies. The decision to use natural colorants can be motivated by various factors. The most common reason they are used is because the finished product is natural or organic. The new U.S. organic regulations require that natural colorants be used in organic foods and beverages and that they meet certain processing and composition requirements. For example, natural colorants may not be extracted with solvents such as hexane or acetone, and they may not contain diluents such as propylene glycol. Thus, many natural colorants do not meet organic requirements, so colorant producers are having to change production methods and reformulate some of their products.

Another reason for using natural colorants is that the desired hue cannot always be obtained or maintained using certified synthetic colorants. This problem has become more acute as various certified colorants have been delisted by the FDA. For example, carmine and certain fruit and vegetable juice colorants can provide a fuchsia shade in acidic applications with vastly superior light stability to FD&C Red No. 3. It is also possible to obtain a tropical red shade using cochineal extract and carmine, which has sulfite resistance and heat stability that is superior to FD&C Red No. 40.

Natural colorants can also be used to take advantage of the unique characteristics of the materials, such as colorants that are indicators in color-changing applications. For example, a dried fruit or vegetable juice colorant may appear red in a dried cereal application, but it will turn purple, blue, or a different shade of red when added to milk. Sometimes a weakness in a natural colorant can be used to achieve a novel result. For example, beet is sometimes added to Bolognese sauce to take advantage of the fact that it browns during heating. This same effect could be used to brown microwave foods or meatless, pink meat analogs.

Another benefit of many natural colorants is that they are less likely to permanently stain clothes and carpet than synthetic colorants. Possible applications range from children's powdered beverages to beverage fountains in movie theaters and restaurants. Reduced staining can also have indirect benefits, such as permitting recyclers to reuse glass containing naturally colored beverages more times.

Natural colorants can also be used to take advantage of their purported health benefits. As has been widely reported, many of the chromophores in natural colorants can provide nutraceutical benefits at food colorant prices. For example, many fruit and vegetable colorants are naturally rich in anthocyanins, which provide antioxidant benefits. A selected summary of the nutritional benefits of natural colorants is provided in Table IV.

Challenges with Natural Colorants. Perhaps the most frequent complaint about natural colorants is their lack of stability. This complaint actually encompasses three problems—shade change with pH, unacceptable fading or browning, and phase separation.

Many natural colorants are pH indicators. For example, fruit and vegetable juice colorants with anthocyanins pigments, such as black carrot, elderberry, grape, red cabbage, purple sweet potato, and red radish, change from orange-red or bluish red to purple to blue and eventually green as pH increases. This color change may occur immediately, or it may take several hours. More natural colorant is needed to achieve the same shade intensity produced by synthetic colorants, and these colorants become less stable as pH increases, particularly in high water activity applications. It is also important to minimize positive metal ion content to prevent fading or a shift in the color of the product. This is seen most often when hard water is used or foods are fortified. The response to metal ions varies from colorant to colorant.

Furthermore, colorants containing anthocyanin pigments are susceptible to fading and, in some cases, browning in the presence of high levels of ascorbic acid. This is more pronounced in colorants containing less intense anthocyanin pigments, such as chokeberry, cranberry, some elderberries, and some grapes. Low levels of ascorbic acid, such as 50–70 ppm, actually tend to improve the stability of the finished product. However, levels above 100 ppm usually increase fading, an effect that is more noticeable in less stable colorants. Whether the effect is significant varies from application to application; however, colorants containing anthocyanin pigments are being used successfully in products containing much higher levels of ascorbic acid than are currently on the market.

Another problem that frequently occurs, particularly with emulsified colorants (e.g., β-carotene, carrot oil, paprika oleoresin), is ringing or sedimentation. This is generally the result of using a colorant with a less stable or broken emulsion or a specific gravity that is too different from the finished product.

Many of these unwanted effects can be amplified, often in nonlinear ways, by placing colorants in flavor, beverage, or other concentrates. This can result in greater fading and browning than expected in untested mixtures. This nonlinear relationship can also result in the disqualification of a potentially adequate colorant by accelerating heat or light instability.

To choose the best colorant for your cereal or snack food application, it is critical that you work closely with your colorant supplier and provide information on the pH (if applicable), kosher requirements, fortification (if any), packaging type, heat processing, and solubility of your application.

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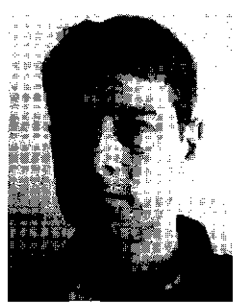
Table IV. Reported health benefits of selected natural colorants

Common Name	Reported Health Benefits
Astaxanthin	Reduces exercise-induced muscle and joint soreness; protects skin from sunburn; reduces instance of carpal tunnel syndrome
β-Carotene	Improves vision
Sodium copper chlorophyllin	Aids in wound healing; freshens breath; may help prevent hepatocellular carcinoma
Fruit and vegetable juice colorants (anthocyanins)	Free radical scavenging helps protect cells; enhances immune function by boosting cytokine production; protects cardiovascular system through reduced oxidation of LDL cholesterol; antiviral activity; mitigates acute hepatopathy; reduces stress
Marigold (lutein)	Protects macular health
Monascus	Reduces cholesterol
Turmeric (curcumin)	Antiarthritic, antioxidant, anti-inflammatory, antimicrobial, antiparasitic, antiseptic, and antitumor effects; lowers blood pressure; improves circulatory system function; improves night vision



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