Converting to Natural Colors: Usage Considerations in Confectionery

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A study conducted at Southampton University in the UK attempted to link the onset of hyperactivity in children with the consumption of certain artificial colorants. Despite the questions raised by the medical community and food associations regarding the validity of the study, natural colors are gaining popularity, particularly in the confectionery industry. Unlike artificial food colorants, natural colors require special formulation considerations, as they are susceptible to many environmental factors including temperature, pH, water activity and light exposure. While the color palette with natural colors is limited when compared to artificial colors, their use is possible in many confectionery applications.

*Anthocyanins*

Many fruits and vegetables ranging from red to deep purple, owe their color to the anthocyanin pigment. Purple sweet potato, red cabbage, black carrot, grape juice, radish and elderberry are popular sources. Anthocyanin pigments are touted for their therapeutic effects on aging, neurological diseases, cancer and bacterial infections. These colorants would replace typical artificial pinks, reds and purples.

Achieving an attractive color is possible in processes that maintain a pH between 2-6. Acylated anthocyanins, particularly purple sweet potato, red cabbage and red radish, exhibit the best light and heat stability. High temperature hard candy processes may benefit from these colorants if color is added as late as possible in the manufacturing process. Browning and fading occurs when the colors are held at high temperatures for an extended amount of time. Proteinaceous confections colored with anthocyanin pigments may exhibit color precipitation and speckling. While some color change may occur,
adding higher concentrations of color may aid with this problem. Panning applications benefit from anthocyanin colorants as they require relatively low temperatures. Proper packaging helps to prolong the life of the natural red colors. Most anthocyanins are Kosher-certifiable with the exception of grape juice color. Additionally, the use grape juice and grape skin extract are not interchangeable. Grape juice color is allowable in confections and other non-beverage foods (21 CFR 73.169) as grape skin extract is restricted to use in beverages. Optimal conditions include a short desired shelf life (3-6 months) and packaging that shields product from light, oxygen and humidity. Grape juice color requires refrigeration unlike other colorants.

Many preparations are available and can be tailored to the specified application. Most liquid preparations are water-based as the anthocyanins functions in the same way as artificial dyes. Propylene glycol carriers are often employed for compound coating and other oil-based applications. Low usage levels are suggested as propylene glycol will change the rheology of compound coating rendering it difficult to work with.

Aronia and elderberry are often used in European confections (E163). 21 CFR 73.260 describes the use of anthocyanins in confections marketed in the United States.

*Betacyanins*

An extract of beets (*Beta vulgaris*), betacyanin or betanin has low heat and light stability. This color, which matches artificial pinks and reds, has a pH range from 4-8 and fares well in fondant applications and confectionery coating applications. Dry applications (ie. colored sugar) would fare well with beet color. A low shelf life should be expected with these products. Iron and/or copper ion fortified confections or products with high water activity may exhibit betanin oxidation leading to discoloration. Adding
low levels of ascorbic acid to formulations may slow this reaction. Kosher beet color is commercially available and is accepted in the United States (21 CFR 73.260) and Europe (E162).

*Cochineal Extract and Carmine*

The cochineal insect (Dactylopius coccus) is the source of cochineal and carmine colorants and is one of the most stable natural colorants available. Cochineal extract is prepared by drying carminic acid-containing female insects and chemically extracting the color. The cochineal extract is has excellent light and heat stability. Its use is typically reserved for aqueous applications due to its inherent solubility characteristics. This colorant can range from yellow-orange at a low pH to red-purple at a higher pH.

Often likened to a lake pigment, carmine is cochineal extract adsorbed on an insoluble calcium or aluminum base. Carmine is water- and oil-dispersible lending its use in compound coating applications and sugar confectionery. As observed in lake pigments, care should be taken to avoid extreme pH environments as this often leads to the cochineal extract “stripping” from the insoluble fraction. Acid-proof carmine is available for extremely low pH applications. Water-soluble carmine is also available. For a stable violet shade, purple carmine is a viable alternative.

Cochineal extract and carmine can be used in all confectionery applications that do not require a Kosher or vegan status in the United States (21 CFR 73.100) and Europe (E120). Carmine is also know to cause asthma and severe anaphylaxis in certain individuals.
**Paprika**

Paprika oleoresin, extracted from *Capsicum annum*, is an oily mixture of natural pigments that give a strong orange color. This colorant has a spicy note that works well with oil-based, complementarily flavored confections. Paprika oleoresin is converted to a water-dispersible form by adding polysorbate. Its light sensitivity is decreased by the addition of ascorbic acid in aqueous applications. Oxygen and light barrier packaging paired with antioxidant ingredients may improve the life of the color. The United States lists paprika oleoresin’s use in food products in 21 CFR 73.345. The European reference is E160c.

**Carotenoids**

Carrot oil, β-apo-8’-carotenal and β-carotene are categorized as carotenoids, a class of natural fat-soluble pigments found in plants and other organisms. Their use is outlined in the Code of Federal Regulations (21 CFR 73.300, 73.90 and 73.95, respectively). In Europe, their use is described in E160a. Like many anthocyanins, carotenoids exhibit heat- and light-lability. Kosher-certifiable colorants, carrot oil and B-carotene are good alternatives to yellow and light orange artificial colors. Adding butylated hydroxytoluene (BHT) or ascorbic acid aids in the reduction of color loss.

Crocin is a carotenoid derived from the saffron or gardenia plant. Gardenia-derived crocin is more popular since saffron products are cost-prohibitive. Used in European confections (E161b), crocin is water-soluble and useful in hard candies as it exhibits good heat stability.

**Annatto**
Expressed from *Bixa orellano*, a tree that lives in tropical climates, annatto is a commonly used alternative to orange artificial colorants. Two forms of annatto exist – bixin, an oil-soluble colorant and norbixin, a water-soluble colorant. Annatto colorants have a slight flavor note similar to nutmeg.

Bixin exhibits low light stability but good heat stability. Like paprika oleoresin, the use of an antioxidant in the presence of bixin may help maintain color longer. Oil-based confectionery applications with light barrier packaging would maintain a good orange color.

Norbixin would give an orange color to hard candies and hard and soft panned products. Products that have high calcium and/or acidity would exhibit speckling, as norbixin would precipitate out of the product. High protein confections would exhibit a shift toward a pink-orange color, which may or may not prove advantageous. High temperatures effect a chemical reaction that brightens the yellow color.

Acid-stable and Kosher annatto are available. The European and US references to annatto’s use are E160b and 21 CFR 73.30, respectively. There are cases of individuals with annatto-related anaphylaxis. Additionally, individuals with Celiac Disease may exhibit the same reaction to annatto similar to that of gluten.

*Curcumin Extract / Turmeric Oleoresin*

The *Curcuma longa* plant is the source of turmeric color. At an acidic pH, it exhibits a bright yellow color. Alkaline conditions generate a yellow-brown color. Curcumin is the powdered color form, while turmeric oleoresin is the oily form. Turmeric withstands temperatures of 140°C for 15 minutes lending to its successful use in hard candies. Other low moisture confections exhibit good light stability with curcumin color.
Sulfur dioxide use should be below 100 parts per million in the confection formulation as this contributes to fading. Typically, high levels of turmeric and curcumin are used to compensate for fading. Kosher-certifiable versions of this colorant are available. The US lists curcumin usage in 21 CFR 73.615 as Europe lists it under E100.

*Riboflavins*

Riboflavin, or vitamin B₂, may serve a dual purpose as a fortifier and a colorant. Ranging from yellow to yellow orange, riboflavin exhibits good stability in many confectionery applications. Kosher-certifiable and acid-stable, its usage requirements are listed in 21 CFR 73.450 and E101. Riboflavin is water- and oil-dispersible lending to its use in viscous and oil-based confectionery applications. Additionally, riboflavin has a bitter taste profile.

*Green and Blue Natural Colorants*

Until recently, blue and green natural colors were unheard of in American confections. Natural color manufacturers have manipulated red cabbage color, which is blue at pH 7, and created a blue color similar to that of Blue #2. By mixing this color with turmeric, one can achieve a green color. Unfortunately, these colors are unstable outside of a pH range of 6-8. These colors, if dispersed properly, can add color to compound coatings and low-acid hard and soft panning applications. High heat would create an off color. Spirulina, a nutritive derivative of blue-green algae, may be a future color alternative to artificial blue colorants.

Chlorophyll-based colors derived from green plants are acceptable in European confections (E140, E141). Copper chlorophyll, a more stable form with a bluer tint, is stable in neutral or alkaline conditions. The cupric form of the colorant may have a
metallic taste profile as copper ions are used to stabilize the chlorophyll molecule. This off flavor can be eliminated by the use of taste masking agents. Usually citrus candies benefit from the use of chlorophyllin colors. Compound coatings are also colored green when using chlorophyll solubilized in oil carriers.

**Caramel Colors**

The Maillard reaction, enzymatic browning resulting from an amino group and sugar in the presence of heat, is responsible for the production of caramel color. Four types of caramel color exist – plain caramel, caustic sulphite caramel, ammonia caramel and sulphite ammonia caramel. Caramel color is one of the most widely used colors and is very stable in many confectionery environments. Caramel color ranges from light to very dark brown. It is Kosher-certifiable and its use with other light-sensitive colors may increase their stability. E150 cites its use in Europe. In the US, 21 CFR 73.85 details its allowed usage.

**Carbon Black**

Like the chlorophyllins, carbon black is restricted from use in the United States, but is popular in Europe. The black colorant, derived from burnt vegetable matter, is extremely stable and used mainly in licorice and black gummi applications. It is only available in solid form and is outlined in E153.

**Iron Oxides**

Iron oxides are naturally occurring iron pigments which can be red, orange, brown or black. All shades are typically dull. Restricted from use in the United States, iron oxides are allowed for use in European products with the exception of Germany. E172 outlines its use in confectionery.
Converting from Artificial To Natural Colors

Pricing, color stability, vibrancy, coloring power and availability are marked differences often noticed when converting from artificial to natural colors. Typically, natural colors are more expensive which limits their use in confectionery. Additionally lower vibrancy and coloring power of most natural colors when compared to artificial colors is also observed. The need to use more color combined with their relatively high cost often eliminates the desire of confectioners with lower-priced products to convert to natural colors. The availability and reproducibility some natural colors is a function of the environment in which many of these color sources are grown. For instance, a disease affecting the cactus plants that serve as homes to cochineal insects, may lead to a decrease in carmine in a given region, leading to price increases, potential color differences and decreased availability. Artificial colors depend only on manufacturing processes.

Organic confections may benefit from organic natural colors. Concerns exist regarding the availability of these colors as few organic growers exist and fewer organic color suppliers are available. Many also use fruit juice concentrates to add flavor and color to confections.

With stability being an issue, natural encapsulation of natural colorants is increasing. These colors exhibit a marked increase in light and heat stability but are also more expensive. Despite this, their usage levels are lower as they function like artificial lakes in most cases.

Labeling
Natural colors are listed in the United States in different ways. The confectioner has the following options for listing the colorant:

- “Artificial color”
- “Color added”
- “Colored with ______ “
- “_______ color”

“Natural color” is not allowed unless the color is expected in the food type. For example, grape juice color in a grape candy can be listed legally as “natural color.” Conversely, purple carmine color in grape candy would not be labeled as “natural color.”

Conclusion

The term *natural* is misleading. Most colorants are not expressed from natural sources and used “as-is.” In the end, the resulting colorant is an impure extract that is modified to a commercially viable form. Artificial colorants certainly have their place. They have excellent stability, brightness and are reproducible. The FDA and other regulatory bodies ensure that artificial colors are safe as they are tested thoroughly and certified.

When selecting colors, natural or artificial, it is important for the formulation and the supplier to understand the regulatory, manufacturing, packaging and storage conditions of the confection. Natural colors should be considered early in the formulation process to ensure the final product is attractive to the consumer.