Going Au Naturel—
Coloring Considerations

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www.GlobalFoodForums.com/CleanLabel
What are “natural” colorants?

Neither FDA or EU has a legal definition for “natural” colorants.

However, consumers & marketing departments have a clear concept of “natural” & artificial colorants.
FDA Colorants Classification

Certified colorants—Synthetic FD&C food dyes for which each manufactured batch must be tested by FDA labs

Color additives for food use that are exempt from certification (Most are naturally derived, n = 35)
Growth market for “natural” colorants

Global sales of “natural” colorants have overtaken artificial colorants*

Consumer concern over safety of artificial colorants

Many “natural” colorants provide health benefits

*Mintel & Leatherhead Food Research, 2013
Impact of the Southampton Study

Effect of synthetic food colorant consumption by 3 yr-old & 8-9 yr old children on hyperactivity

Concluded that the Global Hyperactivity Aggregate (GHA) score was higher

European Food Safety Authority concluded that the Acceptable Daily Intake (ADI) should not be changed

Food Advisory Committee of FDA reviewed issue, FDA took no action

McCann et al., 2001
Functionality of “Natural” Colorants

Less stable to heat, light & O$_2$

May react with other components to produce undesirable flavors & colors

All desired hues may not be possible

“Natural” are more costly
The “Ideal” Natural Colorant*

- Permitted for use in all markets
- No impact on product appearance or flavor
- No change in nutritional profile
- No change in shelf life or stability
- No change in manufacturing processes
- No change to product packaging
- No change to ingredient cost

*Thanks to Cathy Culver, Pepsico
The Real World*

No global consensus on regulations
Matching appearance is challenging
Flavor profile often changes
Usually less stable
Processing & packaging may have to change
Cost will increase

* Cathy Culver, Pepsico
What are some alternatives to those artificial AZO dyes?
For red hues…

**Anthocyanin-based Colorants**

**USA**— Fruit & Vegetable juices, Grape-skin, Grape Color

**Europe**— E 163

Structure variation impacts hue and stability

Suitable for pH < 4.0
Properties of Anthocyanin-based Colorants

<table>
<thead>
<tr>
<th></th>
<th>Hue</th>
<th>pH range</th>
<th>Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grape-skin extract</td>
<td>red-purple</td>
<td>&lt;3.5</td>
<td>fair-good</td>
</tr>
<tr>
<td>Red grape juice</td>
<td>red-purple</td>
<td>&lt;3.5</td>
<td>fair-good</td>
</tr>
<tr>
<td>Black carrot</td>
<td>red-purple</td>
<td>&lt;4.5</td>
<td>good-excellent</td>
</tr>
<tr>
<td>Red radish</td>
<td>red</td>
<td>&lt;4.5</td>
<td>good-excellent</td>
</tr>
<tr>
<td>Purple Sweet Potato</td>
<td>red-purple</td>
<td>&lt;4.5</td>
<td>good-excellent</td>
</tr>
<tr>
<td>Purple corn</td>
<td>red-purple</td>
<td>&lt;4.5</td>
<td>good</td>
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Betalain Pigments
Source: Beet powder & Beet Juice

Express red color throughout the pH range of foods

Water-soluble (greater H₂O-solubility than anthocyanins)

Very unstable to light & heat

“Earthy” flavors can be problematic

Suitable for frozen desserts
Cochineal & Carmine

H$_2$O/EtOH extract of female cochineal insect

*Dactylopius coccus costa*

Carmine is the Ca-AL lake of carminic acid

Extremely stable to light, heat, & oxidation

Relatively high-cost and non-kosher
Tomato Lycopene Extract

H₂O-insoluble

Oleoresins, powders & H₂O-dispersible preparations commercially available

Yellow → Orange → Red hues

Susceptible to oxidation

Stable through broad pH range
Carotenoids... for yellow to orange hues

- Lipid soluble
- Susceptible to oxidation

Some H₂O-dispersible preparations have small particle size that approaches visual clarity
<table>
<thead>
<tr>
<th>Colorant</th>
<th>Hue</th>
<th>pH range</th>
<th>Stability</th>
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</thead>
<tbody>
<tr>
<td>Annatto</td>
<td>Yellow to orange</td>
<td>3.0-8</td>
<td>Fair-good</td>
</tr>
<tr>
<td>β-Apo-8'-carotenal</td>
<td>Orange</td>
<td>3.0-8</td>
<td>Fair-good</td>
</tr>
<tr>
<td>Astaxanthin (fish feed)</td>
<td>Orange-red</td>
<td>3.0-8</td>
<td>Fair-good</td>
</tr>
<tr>
<td>Canthaxanthin</td>
<td>Orange-red</td>
<td>3.0-8</td>
<td>Fair-good</td>
</tr>
<tr>
<td>β-Carotene</td>
<td>Yellow-orange</td>
<td>3.0-8</td>
<td>Fair-good</td>
</tr>
<tr>
<td>Corn Endosperm Oil (chicken feed)</td>
<td>Yellow</td>
<td></td>
<td>Fair-good</td>
</tr>
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</table>
Annatto

Extract of date palm seed

Bixin, (R = CH₃) & Norbixin, (R = H)

Both H₂O & Lipid-dispersible preps are available
Tumeric & Turmeric Oleoresin

Source: Rhizomes of *Curcuma longa*

Spice giving characteristic color & flavor to mustard, pickles, curry powder

Unstable to light; susceptible to oxidation

Anti-carcinogen, anti-inflammatory
Saffron—Intense Yellow Pigment

Crocin, $R = \text{gentiobiose}$

Source: Dried stigma of Crocus sativus flowers

Stable to light & heat

$—$ Very expensive
Chlorophyll... for green hues

Na-Cu Chlorophyllin approved in USA for dry-mix beverages

Cu chlorophyllin & Cu chlorophyll complexes approved for wide usage in EU
Blue...very limited options

Iradooid pigments—Geniposides become blue with exposure to glycosidases & amino acids in presence of oxygen

Sources:
- Amazonia Huito fruit
- Gardenia (restricted to Japan)
Spirulina Extract – A New Blue

H$_2$O extract of cyanobacterea *Arthrospira platensis*

Phycobillin photosynthetic pigment (phycocyanins)

Approved for confections & chewing gum
Caramel Colorants… for brown color

Manufactured via Maillard Reaction—sugars + acids/alkalis + ammonium & sulfite compounds

H$_2$O-soluble, amber $\rightarrow$ reddish brown $\rightarrow$ dark brown

Differ in colloidal charge

Preparations for soft drinks, alcoholic beverages

Account for 90% by weight of all colorants produced
Black & White

EU permits vegetable carbon black

Carbon black delisted in USA; replaced by adding a combination of all colorants

TiO$_2$ used as whitening agent in confectionary baked goods, dairy products
“Natural Colorants”
Not a stock commodity…

The same colorant can vary in price…

… and also vary in purity, tinctorial strength, shade of color, presence of unwanted flavors, stability to heat and light, tendency to precipitate, and suitability for individual applications.
Looking ahead— What’s on the horizon?

New sources— Edible plants with high pigment content, desirable hues, good stability.

Plant breeding, traditional vs. GMO. Patents vs. proprietary

Tissue culture?
Improved processing technologies

Enzymes as processing aids to increase recovery
Filtration & microfiltration technologies
Micro-encapsulation for stability and protection from oxidation
More efficient evaporators and dryers
Resin treatments, membrane processes for flavor removal & pigment concentration
<table>
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<th>Improved Extraction Technologies</th>
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<tr>
<td>Supercritical extraction with CO₂</td>
<td>Ohmic heating-assisted extraction</td>
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<tr>
<td>Pressurized liquid extraction</td>
<td>Continuous counter-current extraction</td>
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<tr>
<td>Microwave-assisted extraction</td>
<td>Solid-phase extraction</td>
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<tr>
<td>Ultrasound-assisted extraction</td>
<td>Microextraction</td>
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Adulteration of “Natural” Colorants

Are a high-value item

High-price + limited availability →

Temptation for cheating in the marketplace
Thanks!

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Acknowledgements

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DD Williamson
Food Ingredient Solutions
GNT USA Inc.
Naturex
ROHA Food Colors
Sensient Colors
Going Au Naturel—

Questions?

Comments?