LIBERTY Comparing the Properties of Anthocyanins with FD&C Blue No. 1

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Background

Colorings enhance the physical appearance of these items to make it more enjoyable for the human consumer. Natural dves. like anthocyanin, produce multiple colors in God's creation and are found in fruit, vegetables and plants. Environmental factors, such as pH, cause the difference in color. His products have health benefits built into the system of it, blessing our human bodies with flavor and health benefits (Table 1) [1]. Synthetic dyes, like FD&C Blue No.1 by men. These were introduced a century ago and tend to be brighter and more enjoyable to the eyes but unhealthy (Table 2) [2].

Biblical Connection

The color blue holds a special part in Christianity and the Bible. Blue is a symbol of the heavenly realm, which reflects the power and glory of God [3]. The Tabernacle was also imprinted with this color. The curtains, veils, Ark of the Covenant, and furniture were lined with blue to symbolize the divine nature and capture the spiritual connection between God and His people [3]. Specifically, sapphire blue symbolizes the glory and majesty of God and his heavenly throne. Sky blue represents the the peace and trust we have with God [3].

Research Ouestion

This study will review red cabbage, a producer of anthocyanin, and FD&C Blue No. 1 and analyze them for different consumer preferences in dves including fade resistance, light stability, pH, and toxicity. Red cabbage powder for anthocyanin and FD&C Blue No.1 powder will be materials analyzed against Gatorade® and other blue sport drinks.

Methods

To get a background of what the dyes are, how they are used, and the preliminary toxicity information, a literature search was utilized. Key words used in databases such as CAS Scifinder and Science Direct include "Anthocyanin", "FD&C Blue No. 1", "Blue Food Dye", "Blue Food Dye; Natural", and "FD&C Blue No.1; toxicology" (Figure 9).

This proposal is to research anthocyanin in a form of cyanidin chloride (Figure 1) and FD&C Blue No. 1 (Figure 4) [4], and their properties that lead to the brightness of color, fade resistance, toxicology, and pH. HPLC tests will be run with red cabbage powder (Figure 2) (Figure 3), FD&C Blue No. 1 powder (Figure 6), a blue sports drink, and filtered berry juice to find the concentration of dye used in these products. Red cabbage powder will be utilized for cost-efficiency, solubility, and because more than 10 g/kg of different anthocyanins are present [5]. Both powders and drinks will be tested with UVvis spectroscopy to identify how much dye is contained. The UVvis spectrometer will also describe the absorbance characteristics of the two dyes in the products and reveal differences in hue. Two liquid samples of each dye will be created, and one will be held under a UV light for one hour. The control and affected samples are then analyzed by UVvis spectroscopy to determine color changes during the waiting process, indicating a difference in light stability. The pH will be tested by creating different solutions of different acidity with both dyes and comparing color brightness and stability. In high acidic solutions [pH=1-2], the color will be red and in more basic solutions [pH=7-8], the color will be blue (Figure 8) [5]. Toxicology will be tested through a fish model.

Table 1. Advantages and Disadvantages of Anthocyanin [1]

Anthocyanin **Advantages** Disadvantages Prevention and treatment of Very expensive · Not fade resistant with cardiovascular and neurological disorders environmental factors (light.

 Anti-inflammatory humidity, temperature, etc) Anti-cancer · Limited materials depending on Antioxidant season of the year



Table 2. Advantages and Disadvantages of FD&C Blue No. 1 [2]

Figure 1. Chemical Structure of Anthocyanin Cyanidin Chloride [10]



Figure 2. Natural source of Figure 3. Color of red blue Anthocyanin dye in red cabbage powder in cabbage powder [5] water [5]

beverages 1.2 1.0 O 0.8 0.6 Wavelength (nm)

Used for: Medicines, supplements,

jam, confectionaries, fruit

Figure 4. UVvis Spectrum of Anthocyanins in Red Cabbage [12]

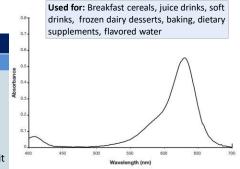
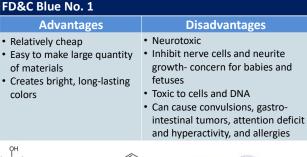


Figure 5. UVvis Spectrum of FD&C Blue No. 1 [10]



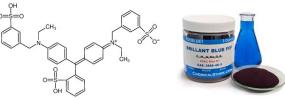


Figure 6. Chemical Structure of FD&C Blue No.1 [2]



Figure 7. Synthetic FD&C Blue No.1 as a powder [2]

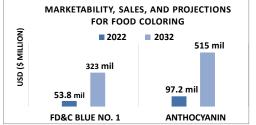


Figure 9. Marketability of Anthocyanin [8] and FD&C Blue No. 1 [9]



Figure 8. color wavelengths and complimentary colors [6]

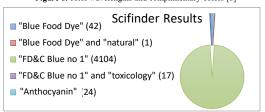


Figure 10. CAS Scifinder Literature Results

Results and Conclusions

Phenol groups found in the anthocyanin compound are responsible for the major health benefits such as the anti-cancer and anti-oxidants properties [1]. The deprotonated compound pulls the color shift from an acidic red color to a basic blue color [1]. Baking soda with the natural dye powders assist in the deprotonation to make a rich blue color.

Conjugate double bonds in the dyes assist in emitting different colors depending on the number of bonds is present, affecting the energy level as a result. The HOMO-LUMO gap explains the difference, or "gap", in energy between the highest occupied and the lowest unoccupied molecular orbital. The more conjugation a chemical has, the HOMO-LUMO gap is decreased, lowering the energy of light is needed to excite electrons and changing the color in the process [7]. The gap value can be mathematically predicted with the energy equation: $E = hc/\lambda$. The value for anthocyanin and FD&C Blue No.1 are 2.39 eV and 1.96 eV, respectively. The value for the absorbance of orange is 2.06 eV [14]. FD&C Blue No. 1 is closer to this value, which explains the deep and true blue this chemical creates.

Absorbance values and wavelengths are dependent on the level of energy present, which are both absorbed and emitted. A color is absorbed and the complimentary color of the opposite level of energy will be emitted (Figure 8) [7]. The orange wavelength (585-620 nm) is absorbed by the compound, and the blue wavelength (440-490 nm) is emitted to what the physical eve can perceive [7]. Both anthocyanin and FD&C Blue No. 1 have a total of eight conjugated bonds in their chemical structure, which is necessary to give off the blue color.

The current and projected marketability of anthocyanin and FD&C Blue No. 1 can be seen in Figure 9 [8] [9].

The preferred article was written in Spain, where 1.61% are evangelicals [2].

Future Work

Similar experiments will be conducted further on a wider variety of materials. Fruit loops, colored icing, Jello, and fruit snacks will be analyzed for the following natural and synthetic dyes: anthocyanin, FD&C Blue No. 1, FD&C Blue No.1, methylene, cyanidin glucoside, and delphinidin.

References and Acknowledgments

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