Ocean Insight

Application Note

KEYWORDS

- Beverages
- Food dyes
- Fruit and vegetable extracts

TECHNIQUES

- Absorbance spectroscopy
- UV-Vis spectroscopy

APPLICATIONS

- Product characterization
- Color analysis
- Quality control

Spectroscopy of Sports Drinks

Absorbance Measurements Reveal Color Characteristics

Written by Yvette Mattley, Ph.D.

Beverages designed to replenish vital nutrients have been around since the late 1920s, when they were first developed to provide essential nutrients to the sick. In the decades since then, these beverages have grown to a multibillion dollar industry globally **[1]**.

Consumers are faced with a dizzying array of choices, with drink composition ranging from simple water, sugar and electrolytes to more complex mixtures containing natural ingredients with added vitamins and nutrients. Inspired by the recent proliferation of sports drinks and the vast array of choices consumers have available, we were curious to explore the composition of several sample beverages using modular spectroscopy.

Experimental Setup

With an array of ingredients to measure — from food dyes to fruit and vegetable extracts – we opted to build our sport drink setup around the extended wavelength range Flame-S-XR1 spectrometer, which covers 200-1025 nm. By covering this wide wavelength range, we ensured we weren't missing any interesting spectral features. Also, we could have expanded our coverage into the NIR by adding a Flame-NIR (950-1650 nm) spectrometer and using the spectral splicing feature in OceanView spectroscopy software to provide one continuous spectrum from 200-1650 nm.

We paired our Flame-S-XR1 spectrometer with a DH-2000-BAL deuterium tungsten halogen light source to provide illumination from 230-2500 nm. The samples were very optically dense, so we diluted 0.5 mL of each sports drink to 2 mL with water. This decreased the absorbance in the UV and enabled us to see more spectral features in that region. The samples were placed in CVD-UV-1S disposable cuvettes and a 1 cm pathlength cuvette holder; a pair of QP450-1-XSR optical fibers completed the system.

Using this setup, we measured UV-Vis absorbance spectra for 11 different sports drinks, each with a different composition (Table 1). While all the sports drinks shared common ingredients like water, sugar and electrolytes, there were some interesting differences in other ingredients that seemed to correlate to the price of the beverage and that were evident in the absorbance spectra.

Table 1. Composition of Sports Drinks

Flavor	Color	Sweeteners	Other Ingredients	Dye
Fruit Punch 1	Red	High-Fructose Corn Syrup		Red 40
Fruit Punch 2	Red	Dextrose		Red 40
Fruit Punch 3	Red	Sugar, Sucralose		Red 40
Lemon-Lime	Yellow/Green	Dextrose		Yellow 5
Orange	Orange	Dextrose		Yellow 6
Grape 1	Purple/Red	Pure Cane Sugar	Coconut Water Concentrate	Grape Juice Concentrate
Fruit Punch 4	Red	Pure Cane Sugar	Coconut Water Concentrate	Vegetable Juice Concentrate
Açai-Blueberry Pomegranate	Purple/Red	Crystalline, Fructose, Stevia		Fruit and Vegetable Juice
Cherry	White	Dextrose		None
Grape 2	Clear	Sucralose		None
Lemonade	White	Stevia Leaf Extract		None

Experimental Setup

For our initial evaluation, we focused on the ingredients that give rise to the color of the beverage. Sports drinks come in a wide array of bright, beautiful colors. This color is not native to the primary ingredients that make up the beverages (water, sugar, electrolytes and other nutrients) but is added to make the beverage more appealing to the consumer. Manufacturers use food dyes or natural ingredients like fruit and vegetable concentrates to color their products.

The sports drinks we evaluated fell into two groups. One group was colored with commercial food dyes and composed primarily of water, sugar and electrolytes. The other group had additional vitamins and nutrients with either no food dye or with natural fruit and vegetable extracts to provide color. As you'll see, the absorbance peaks arising from these colorants were the main spectral features we observed in the data.

In the sports drinks containing food dyes, we observed numerous peaks across the UV and Visible range **(Figure 1)**. As expected, the spectral features observed are similar for all three Fruit Punch sport drinks containing red dye 40 (Allura Red AC) and for the Lemon-Lime and Orange sports drinks containing yellow 5 (Tartrazine) and yellow 6 (Sunset Yellow FCF), respectively. Even though all three dyes are azo dyes, commonly used in food and textile production, they have unique chemical formulas and structures that give rise to different absorbance spectra. Also, although the Cherry sports drink sample has a similar composition to the other beverages, it contains no colorants.

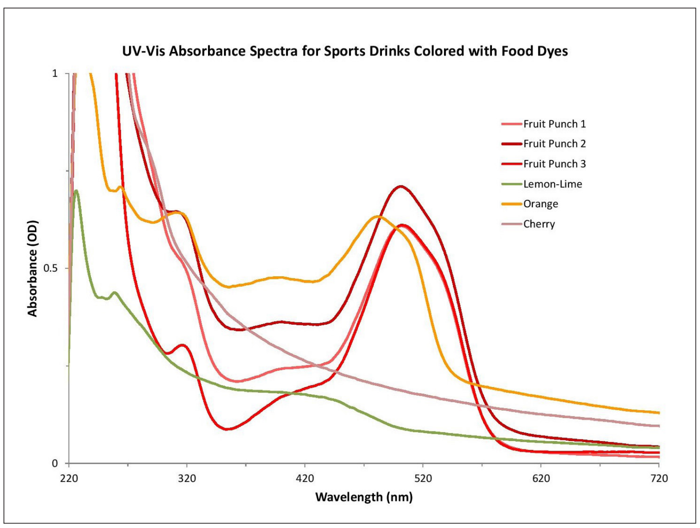

Figure 1. Absorbance spectra of sports drink samples containing food dyes reveal similar characteristics across UV-Vis wavelengths.

When sports drinks get their color from natural sources like fruit and vegetable extracts, the spectra are very different from those colored with food dyes **(Figure 2)**. All the sports drinks contain vitamins and other nutrients in addition to electrolytes, but only the Grape 1, Fruit Punch 4 and Acai-Blueberry-Pomegranate drinks use fruit and vegetable juice extracts to give the sports drinks their color. The other drinks shown in **Figure 2**, Grape 2 and Lemonade, only contain added vitamins; they do not contain fruit or vegetable juice extracts. None of the samples contains food dyes.

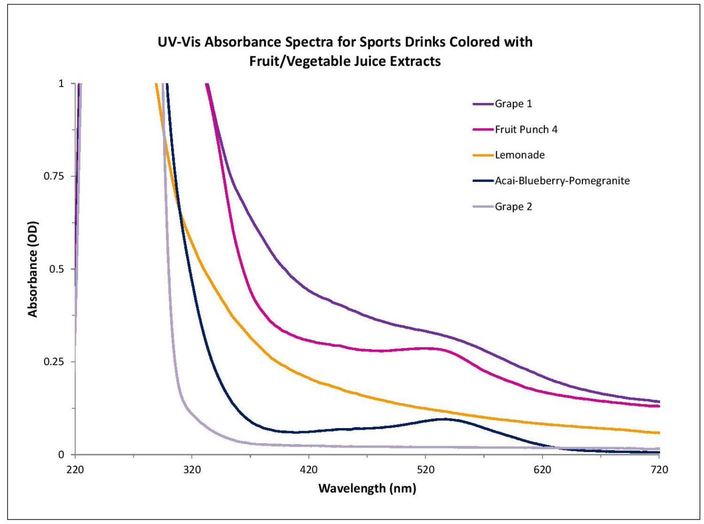

Figure 2. Sports drinks that rely on fruit and vegetable extracts for their color have reasonably consistent absorbance spectra between 320-720 nm.

When fruit and vegetable extracts are used to provide color, an absorbance peak can be observed between 500-600 nm. This peak, observed only in the sports drinks containing fruit and vegetable extracts, arises from the absorbance of plant pigments found in the extracts. Flavonoid pigments like anthocyanin are known to have strong anti-oxidant properties, so the presence of these compounds could add an additional health benefit to the sports drinks — if they are present in high enough concentrations. The use of these natural ingredients does seem to affect the price of these premium sports drinks, but the extra expense may be worth it to the most health conscious consumers.

Conclusions

With these simple UV-Vis absorbance measurements, we've begun to explore just one aspect — color — of the complex mixture that comprises a sports beverage. As the next step in our analysis, we could dilute our samples further to decrease the absorbance levels in the UV so we could evaluate the unique spectral features in that region. Also, we could measure spectral data for the pure samples of the primary components to help us identify the spectral features that arise from these ingredients. There is so much we can explore about these beverages using modular spectroscopy.

The power of the modular spectroscopy approach is that we can easily reconfigure and add on to the setup used for these simple UV-Vis absorbance measurements to look at other sports drink characteristics. For example, using the Flame spectrometer's interchangeable slit feature, we could reconfigure our setup from absorbance to fluorescence to evaluate compounds found in sports drinks like riboflavin and pyridoxine. Also, we could build a modular Raman spectroscopy system using a QE *Pro*, taking advantage of its sensitivity to explore the vitamin and electrolyte composition of the beverages.

That's the beauty of the modular spectroscopy approach. With a user-configurable spectroscopy system, you can easily switch between measurement types to learn more about your samples than you could from a fixed, benchtop instrument designed to measure just absorbance. Quenching your thirst for simple, versatile measurement tools is a victory for everyone interested in using optical sensing to learn more about the world around us.

References

[1] MarketsandMarkets: Global Sports and Energy Drinks Market is Expected to Reach $52 Billion by 2016, excerpted from report at marketsandmarkets.com/PressReleases/energy-drinks.asp.

www.oceaninsight.com

info@oceaninsight.com • **US** +1 727-733-2447

EUROPE +31 26-3190500 • **ASIA** +86 21-6295-6600

090419