APPLICATION NOTE

EVALUATING THE TRANSMITTANCE SPECTRUM AND CIELAB COLOR COORDINATES OF RED CABBAGE EXTRACT AT DIFFERENT PH VALUES

INTRODUCTION

The molecular structure of many substances can be altered according to the concentration of hydrogen ions in aqueous solution. Acidic aqueous solutions has higher hydrogen ion activities and are measured to have lower pH values than basic or alkaline solutions. Changes in molecular structure due to the high concentration of hydrogen (H+) or hydroxide (OH-) ions, generally affects the light absorbing properties of these substances [1,2].

The red cabbage has a natural pH indicator that will change color according to the pH of the solution. This vegetable contains water-soluble and natural pigments known as anthocyanins, see Figure 1. Anthocyanins are responsible for the colors ranging from red to blue of most fruits, flowers, leaves, and some vegetables [3,4].

Keywords:

Transmittance Spectra;

DWHP Light Source;

FLEX Spectrometer;

Red Cabbage Extract;

Standard Cuvette Holder;

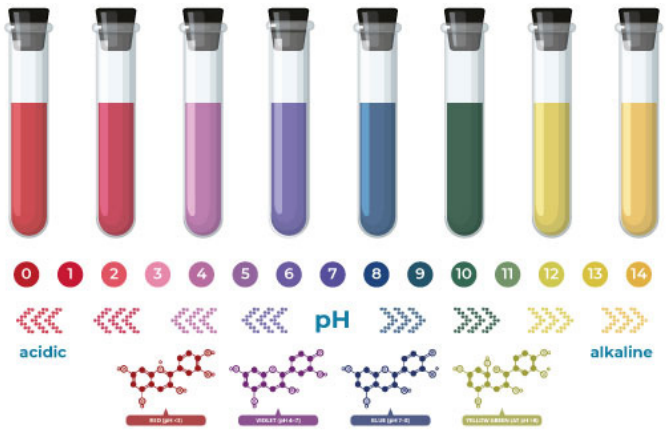

Figure 1 – Solution color and molecular structure variation of red cabbage extract with the pH.

In this Application Note, we combine a high-power tungsten-halogen light source (W20) with a FLEX spectrometer and a transmission probe to measure the transmission spectrum and CIELAB color system of red cabbage extract at different pH values.

MATERIALS & METHODS

Reagents

· Red Cabbage Extract;
· Sodium Hydroxide (NaOH; MW ≈ 39.99 g/mol);
· Hydrochloric Acid (HCl; MW ≈ 36.46 g/mol);
· Distilled Water (H2O; MW ≈ 18.01 g/mol);

Instruments and Accessories: (fig. 2)

· W20 light source;
· FLEX RES Vis/NIR Spectrometer
· Transmission Probe with 400 µm and 10 mm of pathlength;
· pH Meter;

Figure 2 – W20 Light source (1), FLEX spectrometer (2), and transmission probe (3) were used to evaluate the transmittance spectra and CIELAB color coordinates of red cabbage extract.

EXPERIMENTAL PROCEDURE

1. Boil the red cabbage in a cup for 20 minutes;
2. Let cool before removing the red cabbage;
3. Add 20 mL of water to seven cups.
4. Adjust the pH of each cup;
5. Add to each cup 5 mL of the concentrated red cabbage extract;
6. Measure the transmittance spectra and register the color coordinates of each solution;
7. The instrument's parameters used in the LightScan software were changed according to the solution measured;

Table 1 – Instrument settings used for experimental absorption measurements.

Parameter	Used Settings
Integration time (ms)	16
Average	100
Smoothing	3

RESULTS

The transmittance spectra of the aqueous solutions with the red cabbage indicator are presented in Figure 3.

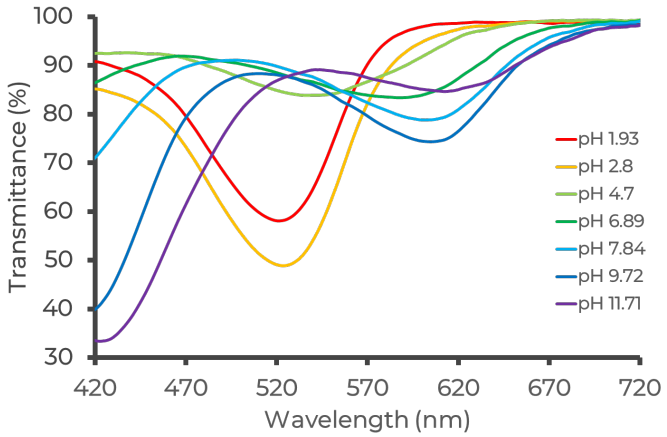

Figure 3 – Transmittance spectra of the seven aqueous solutions with red cabbage at different pH values.

As expected, the red cabbage extract is very sensitive to pH with the operational wavelength range being in the visible region (from 420 to 720 nm), see Figure 3.

At the lowest pH value measured (around 1.9), the transmittance spectrum has a band with a minimum percentage between 500-540 nm. Around pH 4.7, 6.9, 7.8, and 9.7, the transmittance spectrum shifts to lower energies and has a band with a minimum percentage between 520-650 nm (as the pH increases, from 6.9 to 9.7, a band with a maximum around 420 nm appears and its transmittance decreases as the pH increases).

Finally, at pH 11.7, two bands are observed: a smaller one around 620 nm and a major one around 420 nm. As the pH shifts from acid to alkaline, the color of all seven solutions change.

The color of each solution can be roughly estimated with the color wheel (by using the data obtained from the transmission spectrum of each solution), see Figure 4, or precisely estimated (measuring the CIELAB color coordinates) using the color mode that is available in the LightScan software.

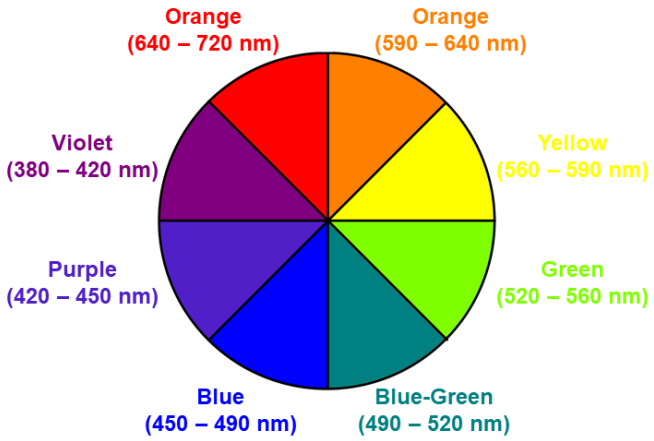

Figure 4 – Color Wheel

Table 2 – CIE 1976 L*a*b* color coordinates of the seven solutions here measured. The illuminant data used was the D65 while the observer data used was the 10-degree.

Solution	_	a	b	Color
1 (pH = 1.93)	82.9	38.3	-5.52	
2 (pH = 2.80)	88.0	25.8	-5.07	
3 (pH = 4.70)	94.1	6.70	-3.14	
4 (pH = 6.89)	94.6	-0.114	-2.40	
5 (pH = 7.84)	94.1	-5.15	1.42	
6 (pH = 9.72)	92.5	-11.7	14.9	
7 (pH = 11.71)	93.7	-9.61	30.9	

CONCLUSIONS

The configuration using the transmittance probe combined with the tungsten-halogen light source and FLEX spectrometer allows for quick and accurate measurements of the transmittance spectra and color coordinates of solutions. This configuration is simple and practical to use for measuring the transmittance and absorbance of solutions in large containers.

REFERENCES

1. B. Valeur, M. N. Berberan-Santos (2012) Molecular Fluorescence: Principles and Applications. Second Edition. Wiley-VCH Verlag.

2. J. R. Lakowicz (2006) Principles of Fluorescence Spectroscopy. Third Edition. Springer Science.

3. V. Cheynier (2021) Anthocyanins in Food. In R. Burke, A. Kelly, C. Lavelle, H. T. Kientza (Eds), Handbook of Molecular Gastronomy: Scientific Foundations and Culinary Applications. CRC Press.