LAAN-A-UV-E040

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Application News

No.A477

Spectrophotometric Analysis

Color Measurement of Food
— Color Measurement in Sugar and Juice —

Foods come in a wide variety of colors, providing visual enjoyment in our lives. These colors also play a role in enhancing or reducing our appetite, and are an important factor in visually determining food quality. Color is a sensory-related phenomenon, but by conducting measurement of food samples using a spectrophotometer to express the color as an objective numerical value, it is possible to compare color quantitatively among multiple samples.
Here, we conducted measurement of sugar and juice samples to determine their color values. For sugar, we used castor or "superfine" sugar, soft brown sugar and brown sugar, etc. as samples, and conducted measurement using a powdered sample holder to compare the color among the samples. For juice, we measured the difference in color between vegetable juice and fruit juice using a screw-cap vial to conduct the measurements and investigate the differences in color.

Fig. 1 Sugars (A – F)

Measurement of Sugars

We prepared measurement samples for each of 6 types of sugar to be analyzed. Table 1 lists the 6 prepared samples designated using the letters A – F. The sugar varieties used for measurement are shown in the photograph of Fig. 1. It is clear from the photographs that except for A, all of the sugars are yellowish. Fig. 2 shows the powder sample holder used for the measurements. At the left is the sample cell with a built-in glass window plate, and at right is the holder used for mounting the window plate-mounted sample cell in the integrating sphere. The window plate-mounted cell packed with sample B is shown in the photograph of Fig. 3. Samples that do not easily harden into a clump may spill out of the integrating sphere sample dish, but this sample loss can be prevented by using a window plate-mounted cell.

Table 1 Six Measured Sugars

Sample	Sugar Name
A	Castor sugar
B	Table sugar
C	Table sugar
D	Soft brown sugar
E	Processed brown sugar
F	Processed brown sugar

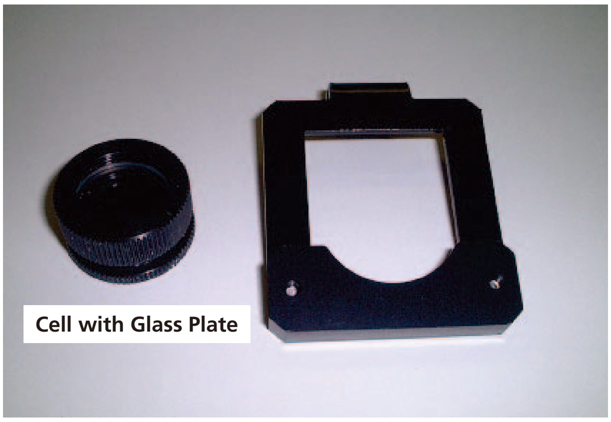

Fig. 2 Holder for Powder Sample

Fig. 3 Sample B Set in Cell with Glass Plate

Measurement Results for Sugars

The sample was placed in the integrating sphere as shown in Fig. 4, and the total light reflectance was measured in the visual region of 380 nm to 780 nm. Each sample type was measured twice, replacing the sample in the cell for each measurement. In addition, baseline correction was conducted using a cell filled with barium sulfate as a reflectance standard.
The measurement results and measurement conditions are shown in Fig. 5 and Table 2, respectively. The reflectance of Sample A showed almost no change over the measurement range, confirming its achromaticity. The samples other than A showed relatively low reflectance in the blue region below 500 nm, and relatively high reflectance in the green and red regions above 500 nm, indicating that they belong to the yellow color system, consisting of a mixture of these green and red colors.

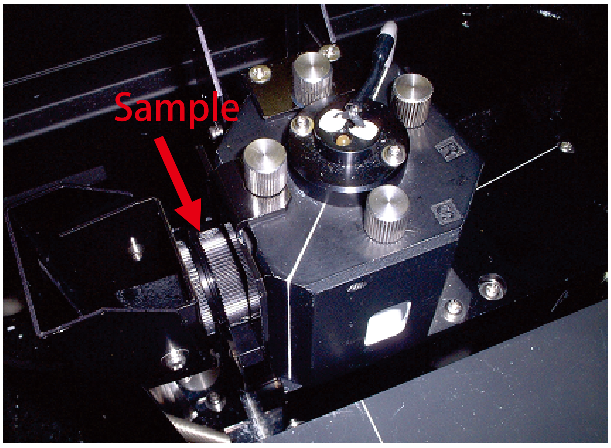

Fig. 4 Sample Set in Integrating Sphere

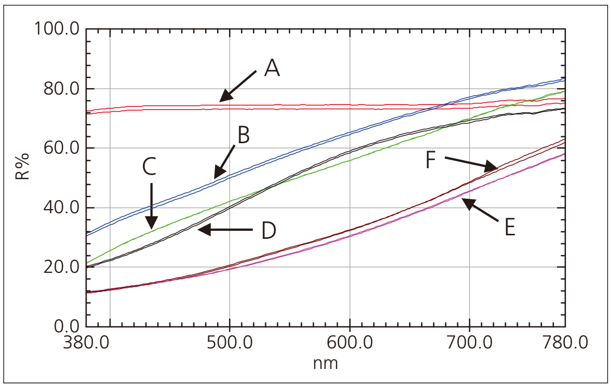

Fig. 5 Total Luminous Reflectance Spectra of Samples
Red: A, Blue: B, Green: C, Black: D, Purple: E, Brown: F

Table 2 Analytical Conditions

Instrument	:UV-3600 Ultraviolet-Visible-Near-Infrared Spectrophotometer MPC-3100 Large-Sample Compartment (with built-in integrating sphere)
Measurement wavelength range	:380 nm – 780 nm
Scan speed	:Medium
Sampling pitch	:2.0 nm
Photometric value	:Reflectance
Slit width	:8 nm

Sugar Color Calculation

Using color measurement software, we calculated the color values of the L*a*b* color system based on the measurement results shown in Fig. 5. Those results are shown in Table 3. The calculations were conducted based on Illuminant D65 and a 10-degree field of view.
The values of Table 3 are expressed in the L*a*b* color space diagram of Fig. 6, and Fig. 7 shows an expanded view of the region in the vicinity of the plotted points on the a*b* graph (horizontal axis: a* values, vertical axis: b* values) on the right side of Fig. 6.
In the L*a*b* color space diagram, the L values are plotted on the histogram on the left, and the a* and b* values are plotted on the graph plot on the right. In the L* graph, the higher the sample position in the graph, the brighter the color. As can be seen in Fig. 6 and Table 3, sample A is relatively brighter, and E and F are darker. In the a*b* graph on the right, it can be seen that the nearer the sample is to the center of the circle, the duller the color, and the further outside of the circle, the brighter the sample color. The radial direction of the a*b* graph represents the hue, the direction to the right while facing the circle represents reddish, the upward direction represents yellowish, the direction to the left represents greenish, and the downward direction represents bluish. From Fig. 6 and Fig. 7, it is clear that except for A, the samples are reddish yellow.
Thus, it is possible to determine the relative differences in color among samples by displaying the colors in a 2-dimensional chromaticity diagram.

Table 3 L*a*b* Values (D65 lamp, 10-degree field of view)

Data Name	L*	a*	b*
A-1	89.15	- 0.06	0.22
A-2	88.48	- 0.04	0.14
B-1	80.93	3.62	15.72
B-2	80.46	3.76	16.07
C-1	75.55	4.06	17.23
C-2	75.56	4.09	17.20
D-1	75.75	5.01	23.28
D-2	76.12	4.93	23.11
E-1	57.12	7.59	18.03
E-2	56.92	7.58	17.67
F-1	58.84	6.86	19.85
F-2	58.54	7.16	20.17

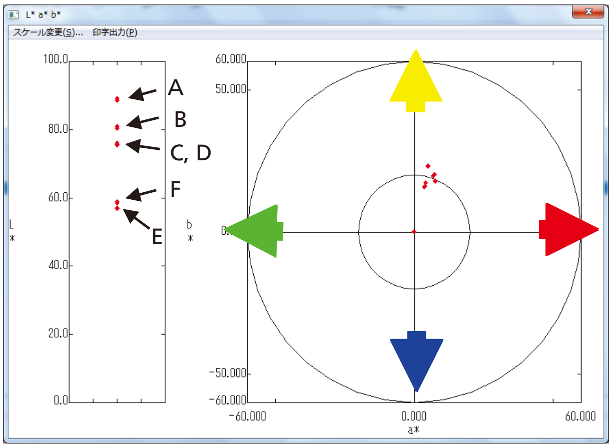

Fig. 6 L*a*b* Color Space

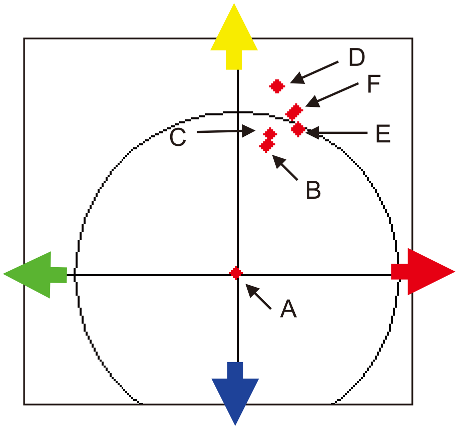

Fig. 7 Expanded a*b* Graph of Fig. 6

Measurement of Juices

We prepared 5 types of juices, including 1 type of tomato juice, 3 types of vegetable juice, and 1 type of carrot juice. Table 4 lists the 5 types of juice samples using alphabetical designations. The samples are shown in the photograph of Fig. 8. The samples were transferred to screw-cap vials, which were placed in the integrating sphere for measurement as shown in Fig. 9. Total reflectance measurement was conducted twice for each sample, using a different vial for each measurement. A positioning jig was used to secure the samples to ensure that they were all measured in exactly the same position. The measurement range used was the visible region of 380 nm – 780 nm, and disposable screw-cap vials were used. In addition, we used as a reference plate for reflectance measurement a Spectralon® fluorine-based resin white plate obtained from Labsphere, Inc. (United States).

Table 4 Five Measured Juices

Sample	Juice Type
A	Tomato juice
B	Vegetable juice
C	Vegetable juice
D	Vegetable juice
E	Carrot juice

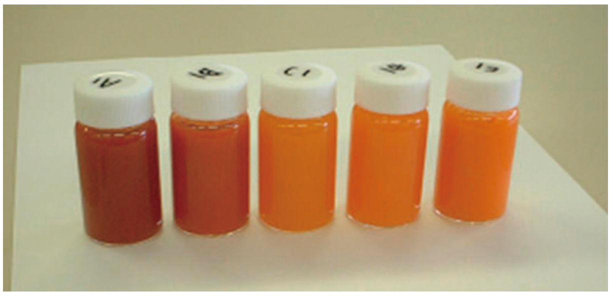

Fig. 8 Samples in Screw-Cap Vials (A – E from left to right)

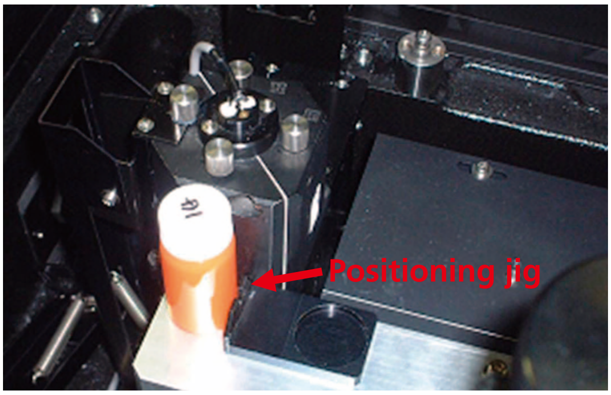

Fig. 9 Sample Set in Integrating Sphere

Measurement Results for Juices

The juice measurement results are shown in Fig. 10, and the analytical conditions are the same as those shown in Table 2.

As can be seen in Fig. 8, samples A and B are more reddish in color, while C, D and E are closer to orange. Fig. 10 reflects those results, in which A and B reflect a lot of light in the red region above 600 nm, while C, D and E reflect some light in the green region in addition to light in the red region. The orange color results from the mixing of those colors.

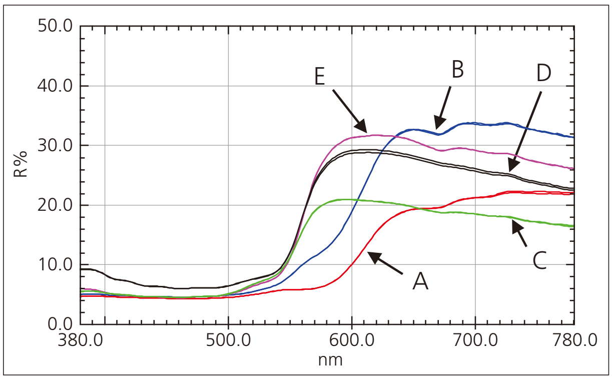

Fig. 10 Total Luminous Reflectance Spectra of Samples
Red: A, Blue: B, Green: C, Black: D, Purple: E

Juice Color Calculation

We calculated the L*a*b* color system values based on the measurement results shown in Fig. 10. Those results are shown in Table 5. The calculations were conducted based on illumination C and a 2-degree field of view.
The values of Table 5 are expressed in the L*a*b* color space diagram of Fig. 11, and Fig. 12 shows an expanded view of the region in the vicinity of the plotted points on the a*b* graph on the right side of Fig. 11. It is clear from Fig. 11 and Table 5 that samples D and E are relatively bright, and that A is dark. It is also clear from Fig. 12 that sample A is closer to red, while C closer to yellow. Also, with respect to color saturation (vividness), sample A is relatively dull in color, while E has a vivid color.

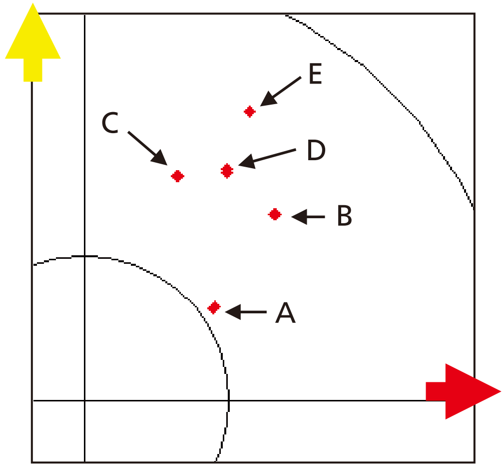

Fig. 12 Expanded a*b* Graph of Fig. 11

Table 5 L*a*b* Values (C lamp, 2-degree field of view)

Data Name	L*	a*	b*
A1	32.46	17.85	12.82
A2	32.44	17.95	12.86
B1	40.67	26.27	25.69
B2	40.66	26.16	25.62
C1	43.79	12.90	30.94
C2	43.87	12.88	30.86
D1	48.80	19.78	31.85
D2	48.51	19.58	31.45
E1	48.94	22.82	39.91
E2	48.95	22.78	39.91

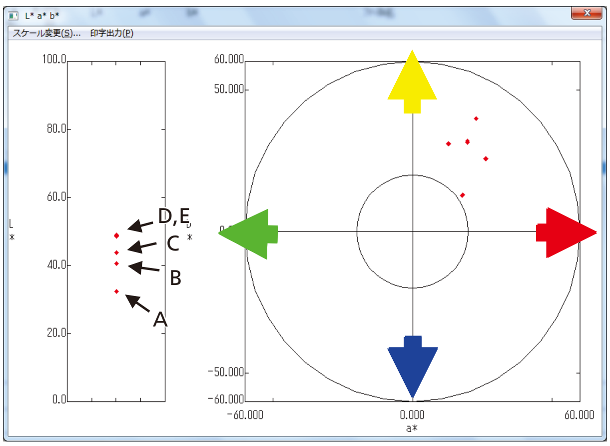

Fig. 11 L*a*b* Color Space

Conclusion

For this Application News, we conducted color measurement for various types of sugars and juices, and compared their colors. The sugars were measured using a powder sample holder, and the juices were measured using screw-cap vials. Reflectance data were acquired in both cases. We were able to express the color differences among samples by obtaining the color values using color measurement software which permitted the results to be plotted on a two-dimensional color space. These expressions can provide useful information for conducting comparative research of product colors.
Thus, by combining the use of an ultraviolet-visible spectrophotometer with color measurement software, it becomes possible to visually and quantitatively grasp the colors of various types of samples.

First Edition: Apl. 2014

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