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Web tools that transform $L^*a^*b^*$ to chroma and hue angle (and vice versa), and that transform spectra to $L^*a^*b^*$ for liquids.

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Abstract

Converting $L^*a^*b^*$ colorimetric data to chroma and hue angle remains challenging for students and researchers, despite these parameters being recommended since the 90's for characterizing biological object colours. The conversion requires non-trivial calculations, particularly for hue angle, which necessitates converting radians to degrees with quadrant-specific adjustments. To address this issue, a series of interconnected HTML-based calculators were developed, enabling both individual and batch conversions between $L^*a^*b^*$ and $L^*C^*h^\circ$ colour spaces. The calculators display RGB colour patches corresponding to entered values and provide bidirectional conversion capabilities. Validation was performed using published data from three independent sources, yielding excellent concordance for both chroma and hue angle. For liquid samples, an HTML page was also developed to transform spectra to $L^*a^*b^*$, chroma, and hue angle values. These web-based tools offer researchers a reliable, user-friendly solution for accurate colorimetric data transformation. All calculators are freely accessible online with comprehensive documentation.

Introduction

Raymond McGuire (1992) explained that the best parameters to characterise the colour of a biological "object" are the Chroma and the Hue Angle, rather than raw L^* , a^* , b^* values. Indeed, Chroma represents the saturation of the colour, and to some extent the intensity or the amounts of pigments, and the Hue Angle refers to the colour that we can all conceptualise easily on a chromatic circle. Finally, L^* represents the lightness: the greater the value the paler the colour; the lower the value, the darker the colour.

I noticed that 30 years later, students and various authors still have difficulty converting raw $L^*a^*b^*$ data to Chroma and Hue Angle, as the conversion is not trivial, particularly for hue

angle, which necessitates conversion from radians to degrees, with specific adjustments depending on where the measurement is located on the chromatic circle.

Thus, I developed a series of HTML pages, with internal cross-links, enabling conversion from $L^*a^*b^*$ to Chroma and Hue Angle, and for the reverse conversion too, and for batch calculations by dropping a .csv file.

Material and Methods

The formulas used were extracted from McGuire's paper (1992), and coded as follows:

```
// Calculate Chroma:  $\sqrt{a^2 + b^2}$ 
const chroma = Math.sqrt(Math.pow(a, 2) + Math.pow(b, 2));
// Calculate Hue Angle
// Note: Excel's ATAN2(x,y) is equivalent to JavaScript's Math.atan2(y,x)
// So ATAN2(a,b) in Excel = Math.atan2(b,a) in JavaScript
let hueRadians = Math.atan2(b, a);
```

For the reverse calculation, from $L^*C^*h^\circ$ to $L^*a^*b^*$, the formulas were coded as follows:

```
// Calculate  $a^*$  and  $b^*$  from LCh
//  $a^* = C^* \times \cos(h)$ 
//  $b^* = C^* \times \sin(h)$ 
const a = C * Math.cos(hRadians);
const b = C * Math.sin(hRadians);
```

The various HTML pages are available on <https://cchervin31.github.io/Lab-color-calculator/lab-calculator-en.html> with embedded links towards other pages.

For liquid samples (wines, clear fruit juices, and syrups), the common practice is to perform spectrophotometric measurements by transmittance.

For wine, the OIV has published a method using spectra from 380 to 780 nm with 5 nm steps (OIV, 2006). Based on this method, an HTML page was also developed. It is recommended to use cuvettes with an optical path length of 1 mm for red wines, and 10 mm cuvettes for rosé and white wines. This has to be specified at the top of the page before pasting the data set. If the sample was diluted because no short path length cuvette was available, the dilution factor can also be entered at the top of the page. Instructions for formatting the data set are also provided.

[https://cchervin31.github.io/spectrum to Lab/v2 Spectrum to Lab batch.html](https://cchervin31.github.io/spectrum%20to%20Lab/v2%20Spectrum%20to%20Lab%20batch.html)

Results and Discussion

The HTML pages are shown in Figure 1, the conversion from $L^*a^*b^*$ to Chroma (C^*) and Hue Angle (h°); in Figure 2, the conversion from $L^*C^*h^\circ$ to $L^*a^*b^*$, in Figure 3, « Why using Chroma and Hue Angle? » ; in Figure 4, batch transform from $L^*a^*b^*$ to C^* and h° ; in Figure 5, batch transform from LC^*h° to $L^*a^*b^*$.

Chroma and Hue Angle Calculator

CIE L*a*b* Color Space

For batch calculations, please [click here](#). | Why using Chroma & Hue Angle? [Read more](#).

For reverse calculations, from L*C*h° to L*a*b*, [click here](#).

L* (Lightness)

a* (Green ← → Red)

b* (Blue ← → Yellow)

Calculate

CHROMA (C*)

79.06

HUE ANGLE (H°)

18.43 °

RGB values: R: 255, G: 114, B: 143

Note: Color conversion uses the CIE L*a*b* to sRGB transformation with D65 illuminant (standard daylight). The displayed color is an approximation and may vary depending on your screen calibration.
Reference: CIE 1976 L*a*b* color space (CIELAB) - ISO/CIE 11664-4:2019

Formulas:

- Chroma = $\sqrt{a^2 + b^2}$
- Hue Angle = $\text{atan2}(b, a)$ converted to degrees [0-360°]

Note: calculations in JavaScript

Figure 1: Seminal page, with output RGB colour pad corresponding to the entered L*a*b* values <https://cchervin31.github.io/Lab-color-calculator/lab-calculator-en.html>

L*C*h° to L*a*b* Calculator

Convert Cylindrical to Cartesian Coordinates

For batch calculations, please [click here](#).

For L*a*b* to L*C*h° conversion, please [click here](#).

L* (Lightness)

C* (Chroma)

h° (Hue Angle)

Calculate

Formulas:

- $a^* = C^* \times \cos(h^\circ \text{ in radians})$
- $b^* = C^* \times \sin(h^\circ \text{ in radians})$

Note: conversions from degrees to radians are performed by the script

Figure 2: Page for the reverse conversion [calculator/lch-to-lab-calculator.html](https://cchervin31.github.io/Lab-color-calculator/lch-to-lab-calculator.html)

<https://cchervin31.github.io/Lab-color-calculator/lch-to-lab-calculator.html>

Chroma and Hue Angle Why Using Them?



Raymond McGuire (1992) explained that the best parameters to characterise the colour of a biological "object" are the Chroma and the Hue Angle, rather than raw L^* , a^* , b^* values. Indeed Chroma represents the saturation of the colour, and to some extent the intensity or the amount of pigments, and the Hue Angle refers to the colour that we can all conceptualise easily on a chromatic circle. Finally, L^* represents the lightness: the greater the value the paler the colour; the lower the value, the darker the colour.

References

- McGuire, R.G. (1992), Reporting of objective color measurements, *HortScience*, 27(12), 1254-1255.
- https://en.wikipedia.org/wiki/CIELAB_color_space

Figure 3: Explanations of the importance of Chroma and Hue Angle in relating to the CIE Lab colour space. [https://cchervin31.github.io/Lab-color-calculator/Chroma and Hue why using them.html](https://cchervin31.github.io/Lab-color-calculator/Chroma%20and%20Hue%20why%20using%20them.html)

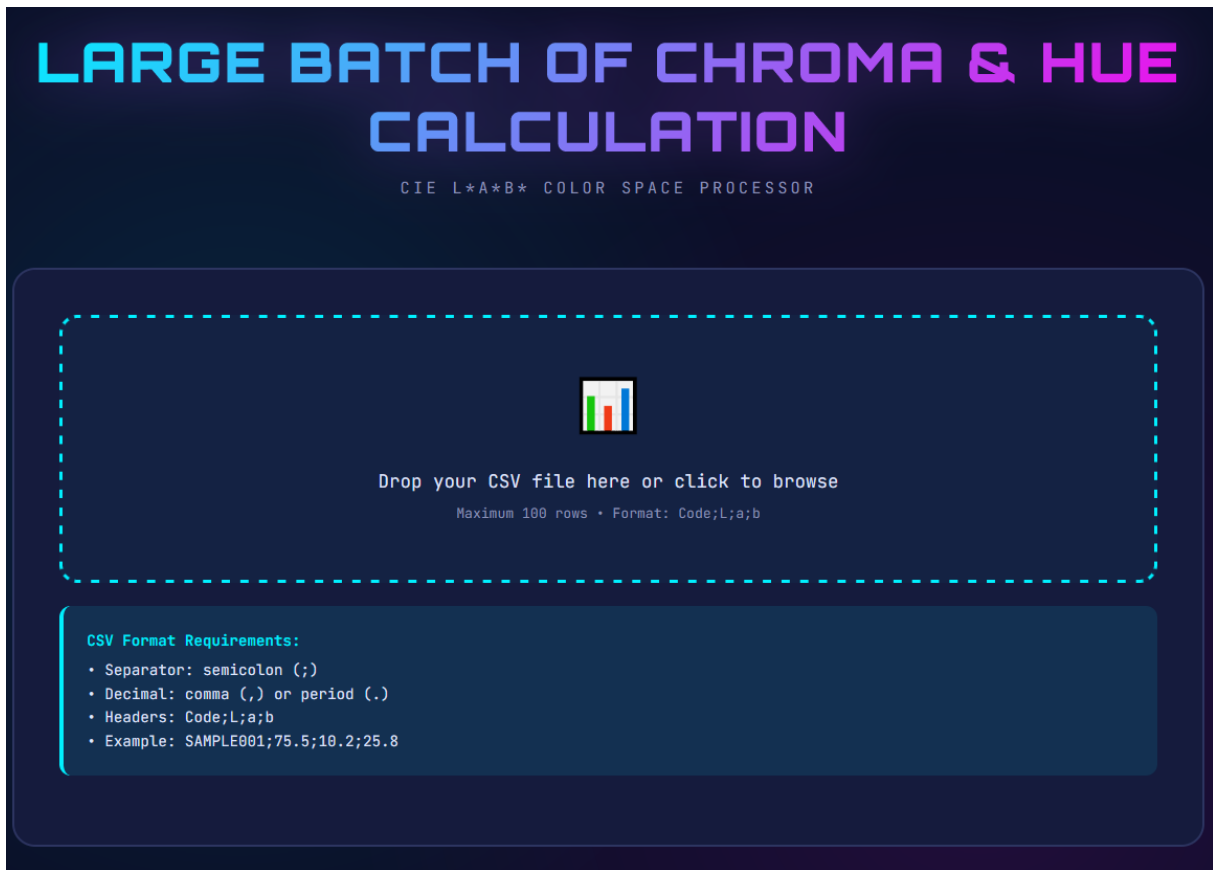


Figure 4: Page for batch calculations of $L^*a^*b^*$ to Chroma and Hue Angle, the input and output are .csv files. <https://cchervin31.github.io/Lab-color-calculator/batch-calculator.html>



Figure 5: Page for batch calculations of $L^*C^*h^\circ$ to $L^*a^*b^*$, <https://cchervin31.github.io/Lab-color-calculator/lch-to-lab-batch-calculator.html>

The calculations performed in these HTML pages were verified as follows.

The verification results are shown in Table 1, and the similarity indices are shown in Table 2.

Table 1: Verification using values from three sources: (1) L^* , a^* , b^* , C^* , and h° from three different articles, and (2) C^* and h° values calculated from L^* , a^* , b^* using the HTML-based calculators described in this article.

	L^*	a^*	b^*	C^*	h°	Color description	C^* HTML	h° HTML
Article 1	61.1	-3.2	3.2	4.5	135	grey	4.53	135
	41	33.2	25.5	41.9	38	red	41.86	37.53
	84.1	-6.7	50.4	50.9	98	yellow	50.84	97.57
	56.2	-32.5	4.9	32.8	172	green	32.87	171.43
	37	-1.3	-27.9	28	267	blue	27.93	267.33
	29.8	-3.1	2.3	3.8	143	black	3.86	143.43
Article 2	76.5	-2	56	56	92	vivid green-yellow	56.04	92.05
	74.4	2	56	56	88	vivid orange-yellow	56.04	87.95
	63.2	1.2	34	34	88	dull orange-yellow	34.02	87.98
Article 3	38.63	15.91	11.47	19.61	35.79	dark brown	19.61	35.79
	48.56	13.33	14.66	19.82	47.73	light brown	19.81	47.72

L^* , a^* , b^* , C^* , h° values obtained from: Article 1) Mirjalili et al. (2019); Article 2) McGuire (1992); Article 3) Hartuti et al. (2019).

As shown in Table 2, with CCCs of 0.999997 (Chroma) and 0.999989 (Hue), the HTML pages reproduce the reference calculations with excellent precision. The biggest observed difference in h° of 0.57° , between 172° and 171.43° , is probably due to intermediate rounding in the reference calculations. Anyway, this is negligible, and the indices show the $L^*a^*b^*$ to Chroma and Hue conversion formulas were correctly implemented.

Note that for conversions between various colour spaces, the website <https://colormine.org/> is very well designed.

Table 2: Similarity indices between Chroma and Hue Angle values published previously (see references in Table 1) and those calculated with the HTML pages advertised in this article. MAE stands for Mean Absolute Error; RMSE: Root Mean Square Error; MAPE: Mean Absolute Percentage Error; r-Pearson: Pearson Correlation Coefficient; R²: Coefficient of Determination; CCC: Lin Concordance Correlation Coefficient.

For Chroma	Index	Value	Interpretation
	MAE	0.04	Excellent if < 0.5
	RMSE	0.045925	Lower is better
	MAPE	0.29%	Excellent if < 1%
	r-Pearson	0.999997	Perfect correlation = 1
	R ²	0.999994	Variance explained (0 to 1)
	CCC	0.999997	Excellent if > 0.99
For Hue angle	Index	Value	Interpretation
	MAE	0.22°	Excellent if < 1°
	RMSE	0.31°	Lower is better
	MAE Circular (accounting for 0°=360°)	0.22°	Accounts for angular nature
	RMSE Circular (accounting for 60°)	0.31°	Accounts for angular nature
	r-Pearson	0.999991	Perfect correlation = 1
	R ²	0.999981	Variance explained (0 to 1)
	CCC	0.999989	Excellent if > 0.99

For liquid samples, such as wines, the HTML page is shown in Figure 6. The data can be pasted as a .csv file, with semicolon separators. In this case, there should be one spectrum per row, with the leftmost cell showing the name of the sample. If the spectrophotometer delivers the spectrum as a column, a transposition step is necessary. Note that the optical path length, entered before the calculation, impacts the output values and may lead to errors if the wrong value was entered.

Once the file has been dropped and the calculation has been performed, it is possible to visualize the results at the bottom of the screen, as shown in Figure 7, and to download the full results table as a .csv file by clicking 'Download'.

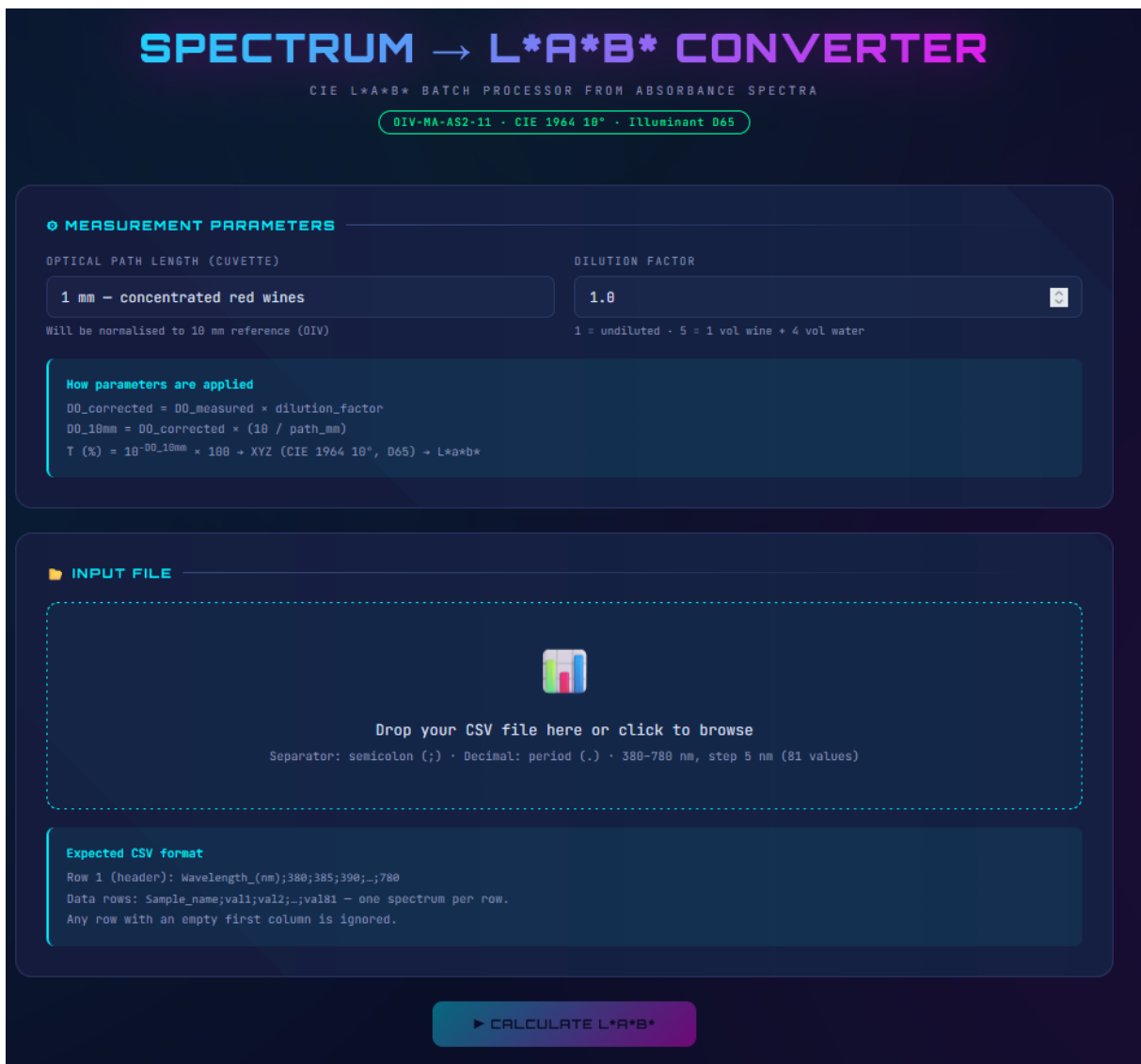


Figure 6: Page for batch calculations of 380-780 nm spectra to L*a*b*, Chroma and Hue angle, for liquid samples.

https://cchervin31.github.io/spectrum-to-Lab/v2-Spectrum-to-Lab_batch.html



Figure 7: Output screen at the bottom of the page, after calculation of Lab*, Chroma and Hue angle values from various spectra, here examples of mint and red berry sirups.

Conclusion

This work successfully bridges the gap between theoretical colorimetric recommendations and practical implementation for researchers studying biological materials. The HTML-based calculators eliminate computational barriers that have hindered proper colour characterization in scientific publications for over 30 years. Rigorous testing against multiple independent datasets confirms the reliability and precision of the implemented algorithms across diverse colour ranges. The user-friendly interface, featuring visual colour patches and comprehensive documentation, makes advanced colorimetric analysis accessible to researchers with varying levels of technical expertise. International collaboration and feedback during development ensured the calculators meet real-world research requirements across different disciplines and geographic regions. Making these tools freely available online democratizes access to proper colorimetric analysis methods regardless of institutional resources or software availability. The standardization of colour reporting practices enabled by these calculators will facilitate better comparison and reproducibility across studies in plant sciences, food technology, and related fields. This contribution represents a practical solution to a widespread methodological challenge, empowering researchers to adopt best practices in objective colour measurement and reporting.

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Literature:

Hartuti et al. (2019) Characteristics of Dried Cocoa Beans (*Theobroma cacao* L.) Color Using Response Surface Methodology. *Planta Tropika*, 7(1), 82-92, <https://doi.org/10.18196/pt.2019.097.82-92>

McGuire (1992) Reporting of Objective Color Measurements. *HortScience*, 27(12), 1254-1255, <https://doi.org/10.21273/HORTSCI.27.12.1254>

Mirjalili et al. (2019) A color-difference formula for evaluating color pairs with no separation – ENS. *Journal of the Optical Society of America A*, 36(5), 789-799, <https://doi.org/10.1364/JOSAA.36.000789>

OIV (2006). Determination of chromatic characteristics according to CIE Lab. Method OIV-MA-AS2-11. <https://www.oiv.int/public/medias/2478/oiv-ma-as2-11.pdf>