



Leather dyeing is both a science and an art.

Image Source: Unsplash user Radek Skrzypczak

Leatherwork is one of mankind's oldest and most consistent art forms, beginning with the development of tanning processes that allowed animal skins to be transformed into flexible, strong materials. As leatherworking methods expanded to include a broad range of possibilities for aesthetic manipulation, leather became prized for its appearance as much as for its practicality and soon saw use in everything from shoes to tools to furnishings and art objects. Since the introduction of more intense and cost-effective [synthetic alternatives to natural dyes](#), leather goods can now be manufactured in a virtual rainbow of colors to meet the needs of discriminating consumers. Today, modern spectrophotometric instrumentation gives leather manufacturers the highest level of color quality control currently available and is playing a critical role in the assessment of new technologies that expand the potential for more consistent and precise leather dyeing.



Computer recipe prediction is improving the consistency of leather dyeing techniques and facilitating color matching between batches, allowing for seamless integration of disparate leather pieces within a single product.

Image Source: Unsplash user Sean DuBois

#### Toward Predictable Leather Dyeing Techniques

Until recently, leather dyeing was still relatively specialized, unpredictable, and expensive, requiring not only an extensive selection of dyes, but careful formulation to achieve both the desired dye behavior and hue. In recent decades, however, researchers have developed new technologies that increase the ease, consistency, and economic feasibility of dyeing by applying modern color theory to leather dyeing techniques. Combining trichromatic dyeing with computer recipe prediction, dyers are able to create virtually any color using only three primary dyes, increasing quality control while reducing both material and labor costs. As noted by Alois G. Puntener:

Consistent application of the new dyeing principle yields economic advantages that are not to be underestimated. An extensive palette of shades can be covered with just a few dyes, with the bonus that the dyer does not have to be familiar with too many types of dye and their properties. This reduces not only the laboratory costs for recipe prediction, but also the costs for dye storage. The extra bonus is the possible use of computer-controlled dispensing equipment whereby the probability for errors and inaccuracies occurring can be greatly limited.<sup>1</sup>

Computer recipe prediction itself is “the prediction of spectral reflectance (and ultimately color) from a given recipe of colorants.” Spectrophotometers allow dyers to confirm the accuracy of these predictions via sophisticated spectral analysis in laboratory environments and within the production line. Today’s range of versatile spectrophotometric instruments are able to produce precise readings in both [RSEX and RSIN modes](#) while also employing [integrated height measurement capabilities](#), making them ideal for evaluating leathers with a range of natural and artificial textures while giving operators the flexibility to [analyze both color and appearance](#). As such, pairing computer recipe prediction with advanced colorimetric technologies offers the best path towards quality assurance.



Artificial Neural Networks are offering a new way forward in leather dyeing, facilitating the accurate coloration of both novel and time-honored leather goods.

Image Source: Pexels user Kai Oberhäuser

#### Applying Artificial Neural Networks to Color Recipe Prediction

Most current color prediction technologies are based on the Kubelka-Munk theory, “an iterative approach [that] tries to minimize the difference between the swatch and predicted tristimulus values.”<sup>2</sup> While this model has greatly expanded opportunities for consistent, cost-effective commercial-scale leather dyeing, it cannot be applied to all situations. As such, researchers are experimenting with applying Artificial Neural Networks (ANNs) to color recipe prediction to overcome the limitations of K-M theory and enhance leather dye formulation.

ANNs are modeled on biological processes and designed to learn over time, allowing it to adapt and become more precise in response to new information. Stephen Westland of the Colour & Imaging Institute at Derby University believes that incorporating these powerful tools offers the leather manufacturing industry a higher level of control while eliminating [the need for complex sample preparation](#). To test his hypothesis, he used a sphere-based reflectance spectrophotometer to “computer color differences between predicted reflectance spectra and actual reflectance spectra” in samples dyed using K-M and ANN-based recipes.<sup>3</sup> The spectral data revealed that ANNs are capable of accurate color prediction and, in fact, outperformed the K-M model.

A similar study focusing specifically on leather dyeing was published in *Coloration Technology* last year and confirmed that ANNs offer superior performance over K-M-based prediction. By averaging samples analyzed via  $d/8^\circ$  instrumentation in RSEX mode, researchers from the Central Leather Research Institute and BSA University in Chennai found that the ANN produced “more reliable and consistent results ... especially for a substrate such as leather,” which has historically been prone to unpredictability. However, both studies note that “in order to outperform the K-M model the ANNs required more training samples,” which many limit its use within small batch leather dyeing or for [manufacturers making frequent color changeovers](#).

HunterLab Innovation

HunterLab spectrophotometers are renowned throughout industry for their extraordinary level of accuracy, precision, and flexibility. With a complete range of portable, benchtop, and inline instruments to choose from, we have the tool researchers and leather manufacturers need to evaluate both new and existing dye technologies both in the lab and on the factory floor. When used in combination with [our sophisticated software packages](#), you have the ability collect, display, and interpret color data, allowing you to easily correlate spectral information to process variables and offering you nearly limitless possibilities for meaningful analysis. [Contact us](#) to learn more about our lineup of products, world-class customer support services, and how we can help you achieve complete color quality control.

1. *Colorants for Non-Textile Applications*, 2000,  
<https://books.google.ca/books?isbn=0080529380>
2. “Artificial Neural Networks for Colour Prediction in Leather Dyeing on the Basis of a Tristimulus System”, 2015, <http://onlinelibrary.wiley.com/doi/10.1111/cote.12123/full>
3. “Artificial Neural Networks and Colour Recipe Prediction”, January 1998,  
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