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PREPARATION AND HANDLING OF COTTON SAMPLES FOR COLOR MEASUREMENT

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Abstract

Cotton samples representing a range of whiteness and trash content, as well as naturally colored cotton samples, were used in evaluating factors that could possibly limit precision and/or accuracy of cotton fiber color measurements taken using color spectrophotometers. In measurements with two instruments, variation in CIELAB data was associated with the size of the instrument aperture used in the measurement. Also, using a fiber cell with sample pressure ranging from 10 to 42 psi, sample lightness, redness-greenness, and yellowness changed with pressure. In each case, the relationship between the color reading and pressure was nonlinear.

Introduction

Color is one of several factors used in quality assessment of cotton fiber. The HVI system, which is used for cotton quality measurements, includes a measurement that addresses two color factors, namely lightness (Rd) and yellowness (+b). These factors are quite similar to two of the three parameters in the Hunterlab and the CIE models, the L* (lightness) and b* (yellowness-blueness) scales. The third parameter, which traditionally has not been addressed in the HVI system is the a* scale, which measures redness-greenness. The system has traditionally used a Nickerson/Hunter 3-filter colorimeter. Through the years, the HVI system, and specifically its color measurement component, have undergone several modifications and improvements. Although there continue to be arguments for further modifications to the system, one of its advantages is that because of its well-established history and regulation, the HVI system and the instrumentation are standardized within USDA and among other users.

In contrast to the HVI system that is used specifically in the cotton fiber industry, textile manufacturers often measure fiber color using the 31-point color spectrophotometers that find many uses in the yarn, fabric, dyeing and finishing industries. Arguably, these instruments can provide better agreement with human color vision, and improved precision in measurements, as well as a choice of instrument/specimen geometries, illuminants, and color models (Berns, 2000; Epps, 2000; Epps and Foulk, 2002; Duckett and Zapletalova, 1999; Xu et al., 1998). However, because there are many such instruments that are available from numerous instrument manufacturers, and because there are different options available for each different instrument, the level of agreement between measurements taken by the different instruments may be less than desirable. Unlike the use of the HVI system for measuring color of cotton fiber, there are no accepted standards for measuring color of cotton with these spectrophotometers. There are no standards that specify the spectrophotometers that are to be used, the fiber sample size, the area of sample that is measured, preparation of the sample, presentation of the sample to the instrument, or pressure applied to the sample at the time the measurement is taken.

The objective of this study was to evaluate effects of instrument, instrument aperture, sample presentation to the instrument, and instrument pressure on CIELAB color measurement of cotton fiber using two color spectrophotometers that are widely used in the textile manufacturing and dyeing industries.

Materials and Methods

Initially, a total of 22 cotton fiber samples was evaluated. These samples included a range of whiteness, yellowness, and trash content, and a range of sample homogeneity. Both "white" cotton, as well as samples of naturally colored cotton were evaluated. Results from three samples, two "white", and one colored, are included in this report.

Samples were prepared by weighing 3 grams of fiber, randomly selected and blended from the whole batch of fiber. In some cases, the batch represented a whole bale of cotton, while in others, samples were prepared from smaller units of fiber provided by growers or processors. Measurements reported represent means of five samples, and three site measurements within each sample. A "site" within a sample is changed by removing the entire 3 gram specimen from the instrument, re-blending it by hand, rotating it and repositioning it in the instrument.

Two instruments were used to measure the samples. The Macbeth "Color Eye" 7000A is a 31-point color spectrophotometer with spherical geometry. The Hunter Labscan XE 31-point color spectrophotometer utilizes 0/45 specimen/observer geometry. A 10-degree observer function was used in all measurements, and illuminant D-65 was specified for the determination of the CIELAB measurements, including L* (lightness), a* (redness-greenness), and b* (yellowness-blueness). A fiber com-

pression cell with fully controllable sample pressure was used with the Hunter instrument. For measurements with the Macbeth instrument, pressure was applied by hand. In this case, the aperture/port geometry allowed viewing of the specimen as it is presented for measurement, enabling the operator to reposition the specimen when folds or shadows appeared in the viewing port due to inadequate pressure.

To evaluate the effect of sample pressure on color readings, the fiber cell was used in conjunction with the Hunter Labscan instrument. Measurements were taken at pressures from 10 to 42 psi, in increments of 2 psi. For these measurements, samples were not repositioned between readings, or as pressure was changed, in order to assure that differences in measurements could be attributed only to pressure, rather than variation within the sample.

Variation in CIELAB measurements among sample and site measurements with respect to instrument aperture was evaluated. For the Macbeth instrument, four aperture sizes were used, namely a VS (very small) aperture of 3x8 mm oval, to circular diameters of 0.5, 1.0, and 1.5 inches. Five instrument apertures were used with the Hunter Labscan instrument: 0.25, 0.375, 0.625, 1.25, and 2.0 inches in diameter.

Results

This study focused on three cotton samples that were generally representative of the full range of samples that were evaluated. Sample A was a Fibermax 966 cotton obtained from the USDA Cotton Quality Research Station in Clemson, SC, from a national study of the year 2000 crop. Sample B was selected from variety trails conducted through the University of Georgia. This sample appeared more homogeneous (contained less trash) than sample A. Sample C, a naturally colored brown cotton, originated from an independent grower.

With increasing pressure from 10 to 42 psi, "white" cotton samples, regardless of trash content, measured lighter, greener, and bluer, while the naturally colored cotton samples included in this study measured lighter, greener, and yellower. Changing pressure affected L* values, or lightness, more than a* (redness-greenness), or b* (yellowness-blueness) values. In each case, the relationship between sample pressure and the color reading was nonlinear. For a typical sample, the range in lightness was two CIELAB units, while the range of a* and b* values was a maximum of 0.3 units. This range in redness and yellowness could be barely visible at the highest level of difference. A difference of 2.0 L* (lightness) units would be clearly visible with the naked eye.

With respect to instrument aperture, variability in L*, a* and b* within each sample decreased as the instrument aperture increased from diameters of 0.25 to 2.0 inches. Although even the smallest apertures are larger than trash particles that might be found in most cotton samples, a larger aperture provides better precision, probably because it allows the instrument to average the measurement across a wider representation of the natural variation in whiteness or yellowness that might occur, even within a well-blended sample.

Conclusions

Because color measurements are influenced by sample handling and preparation, pressure applied to the sample during measurement, and instrument aperture, standards for spectrophotometric measurement of cotton fiber are needed. While these methods are not expected to replace HVI measurements for assessment of cotton quality in the near future, they are nevertheless widely used among cotton consumers in the textile industry. For accuracy and precision in data that are transferred among such users, measurement procedures must be standardized. In addition to specification of instrument type, instrument geometry, illuminant, observer function, and color model (such as CIELAB), standards should include guidelines for control of pressure during measurement and specification of instrument aperture. Ideally, these methods should be correlated, or at the very least, coordinated, with HVI and other color measurement methods.

References

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