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The Use of Regression Equations to Predict the Colour of Wool Using Ceramic Tile Calibration.

By

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Summary

The performance of a previously determined transformed calibration(2) based on a certified ceramic tile was compared to the performance of a calibration based on WRONZ reference wool when measuring samples of clean prepared wool . The results for the three tristimulus values (X, Y and Z) were found to be in close agreement with each other, thereby providing an effective validation of the transformed ceramic tile calibration procedures.

Introduction

There has been a concerted effort over recent years to find a replacement for WRONZ Reference Wool for the calibration of colour machines. Reference wool was originally used as a calibration medium to reduce the between-instrument variation that eventuates when different cell designs are used to present the wool face to the colour measuring instrument. However, the problem with reference wool is that it can only be used once and it has a limited life span of three months. Questions have also been raised with regard to the traceability of reference wool and the accuracy of the tristimulus values that are supplied with reference wool samples.

The use of Spectralon and ceramic tiles as calibration standards for colour measurement has been reported at recent IWTO Meetings. Reed and Marler (2) compared the use of ceramic tile and reference wool calibrations for the measurement of wool colour. They found that the tristimulus values differed by approximately 10 units between the two calibrations, but most importantly the two calibrations were linearly related to one another. It is therefore possible to calibrate using a ceramic tile and transform the tristimulus values obtained under the tile calibration to values that may be expected if the reference wool calibration was used. Similar results were also found when Spectralon was used as the calibration medium (1). A set of regression equations

relating results measured using the ceramic tile calibration to the reference wool calibration were derived (2).

The aim of this trial was to compare the use of these equations in predicting X, Y, and Z with the values obtained using the reference wool calibration.

Materials and Methods

Calibration and Measurement Procedures

Thirty wool samples, that had been previously measured and had a colour range of -1.1 to +6.4 in Y-Z with a mean Y-Z value of 2.1, were selected for the trial. 150g of each sample was scoured, dried and Shirley analysed in the normal manner. The samples were left overnight in a conditioned room in preparation for colour testing.

Calibration and measurement procedures were the same as those used by Reed and Marler (2). The calibration procedure is outlined in the draft test method, IWTO(E)-14-88. Briefly:

- Reference wool calibration and measurement.

The measuring head was removed from its stand and the instrument was calibrated using the black tile and the white Russian opal tile. This style of calibration is known as the manufacturers calibration. The measuring head was then replaced on its support stand and 9 samples of Reference Wool were measured (2 faces for each wool). The mean X, Y and Z values for the 18 readings were recorded as Xm, Ym and Zm.

Using the same calibration, the 30 unknown wool samples were then measured and the tristimulus values for each sample were recorded as Xw, Yw and Zw. The corrected tristimulus values for each wool sample were calculated as follows, where Xr, Yr and Zr are the assigned tristimulus values for the reference wool supplied by WRONZ.

$$X = \frac{Xw.Xr}{Xm} \qquad \textbf{\textit{Equation 1}}$$

$$Y = \frac{Yw.Yr}{Ym} \qquad \textbf{\textit{Equation 2}}$$

$$Z = \frac{Zw.Zr}{Zm} \qquad \textbf{\textit{Equation 3}}$$

- Ceramic tile calibration and measurement.

The second calibration used in this trial was based on ceramic tiles. These tiles were the same as those used for the International Colour Trial(2).The assigned values were certified by an independent organisation (Unisearch, University of New South Wales), traceable to the National Physical Laboratory in the United Kingdom. The certified ceramic tile was used as the white standard in the measurement cell. The tristimulus values of the samples measured with this calibration were transformed to reference

wool equivalent values using the regression equations proposed by Reed and Marler[2] as shown below:

X Reference Wool = -1.65 + 0.88 X ceramic tile ***Equation 4***

Y Reference Wool = -2.08 + 0.88 Y ceramic tile ***Equation 5***

Z Reference Wool = -0.88 + 0.86 Z ceramic tile ***Equation 6***

The values obtained for the 30 wool samples from the tile calibration were transformed using equations 4 to 6 and compared with the values obtained when the reference wool calibration was used.

Results and Discussion

The transformed tristimulus values measured using the certified ceramic tile calibration were compared directly against the X, Y and Z values from the WRONZ Reference Wool calibration procedure by linear regression (Table 1). None of the slopes were statistically different from one and none of the intercepts were statistically different from zero.

Table 1: Regression statistics for the comparison of the transformed X, Y, Z and Y-Z values based on tile calibration against X, Y, Z and Y-Z values from the reference wool calibration.

	R^2	Intercept (SE)	Slope (SE)
X	0.983	-0.02 (1.41)	1.00 (0.02)
Y	0.983	-0.54 (1.43)	1.01 (0.02)
Z	0.986	-0.32 (1.21)	1.00 (0.02)
Y-Z	0.972	0.15 (0.09)	0.96 (0.03)

The regression relationships are presented graphically as Figures 1 to 4.

The measured differences between the transformed tile calibration and the reference wool calibration were also analysed as a function of the measured value using the reference wool calibration. The regression analysis data are presented in Table 2. None of the slopes were statistically different from zero and none of the intercepts were statistically different from zero.

Table 2: Regression statistics for the comparison of the differences in X, Y, Z and Y-Z values from the reference wool calibration.

	R^2	Intercept (SE)	Slope (SE)
X	0.000	-0.02 (1.41)	0.00 (0.02)
Y	0.002	-0.54 (1.43)	0.01 (0.02)
Z	0.000	-0.32 (1.21)	0.00 (0.02)
Y-Z	0.062	0.15 (0.09)	-0.04 (0.03)

The differences between the two methods of calibration were randomly scattered and showed no correlation with the measured values using a reference wool calibration. The differences for each tristimulus value are presented graphically in Figures 5 to 8. Also, the mean differences were not statistically significant at the 95% confidence level.

As these 30 wool samples were a different set of samples to those used to derive the transformed ceramic tile calibration procedures, they provide an effective validation of this calibration procedure.

Conclusion

The trial has confirmed that a transformed calibration based on a certified traceable ceramic standard gives measured results for tristimulus values that are in good agreement with those that are obtained from a calibration based on the WRONZ reference wool.

References

1. Reed, P. J., Baird, K. and Marler, J. W., "Colour measurement of wool: An International round trial evaluating three calibration procedures." IWTO Tech. Cttee. Report No. 13, New Dehli Meeting, March 1994.

2. Reed, P. J. and Marler, J. W., "Calibration of colour instruments with a certified ceramic tile and the WRONZ reference wool." IWTO Tech. Cttee. Report No. 12, Nice Meeting, December 1994.