Expanded Structured Abstract

Comparison of the Color of Ceramics as Measured by Different Spectrophotometers and Colorimeters

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Despite the fact that reported color data measurements[1–4] were made relative to the same illuminant, the measurements vary. This is likely due to the use of different instruments made by different manufacturers. The purpose of this study was to investigate whether there were significant differences among the color data measured by different color instruments.

Materials and Methods: A series of 19 specimens of ceramic fused to Ni-Co alloy was made. Each specimen had a 13.5-mm diameter and a 1-mm-thick ceramic layer. The colors of the ceramic specimens were Vita A2 (Vintage Halo, Shofu) mixed with A1 or A3 in different percentages and changed gradually from yellow to dark yellow. Five color-measuring instruments were chosen: PR 650 (Japan Electronic); SP-1000 (Beijing University); ShadeEye NCC (Shofu and Minolta); ColorEye 7000 (Macbeth); and Chroma Meter (CR-321, Minolta). The primary illuminant D65, with a d2° observer setting, was selected for the five instruments to standardize the measurement conditions. The Commission Internationale de l'Eclairage (CIE) color parameters (CIE L*a*b*) were measured three times and averaged for each specimen for each instrument. CIE L*a*b* values were analyzed statistically by two-way analysis of variance (ANOVA), paired *t* test, and Pearson correlation and regression analysis.

Results: ANOVA detected statistical differences among the CIE L*a*b* color coordinates of the same series of samples measured by the five instruments. On the other hand, Pearson correlation and regression analysis showed strong correlation among the color data coming from different instruments. Equations were derived for transforming one set of color values to another to allow researchers to compare color data among different instruments. The maximum error of predicted L* values ranged from 0.5 to 1.6 when the L* value was calculated and transferred from one instrument to another instrument with the derived equation. The maximum error of predicted a* values ranged from 0.07 to 0.23, and the maximum error of predicted b* values ranged from 0.15 to 0.69.

There was a linear relationship of the L*a*b* values among the five series of color data (Figs 1 to 3).

Discussion: The L*a*b* color coordinates of the same specimens showed high correlation among the five different instruments, and the color data from different instruments were comparable when the same specimens were measured. Although there were statistical differences among the L*a*b* color coordinates from different instruments, derived equations would allow researchers to compare color data from different instruments. The maximum predicted error from transforming calculation was mostly within the range of the color differences that human eyes can hardly detect, meaning that the differences between calculated and actually measured values would not be noticed by most observers.

Only ceramic powder of shade A was measured in this experiment. More research should be done to determine if these equations could be applied to other ceramic powders.

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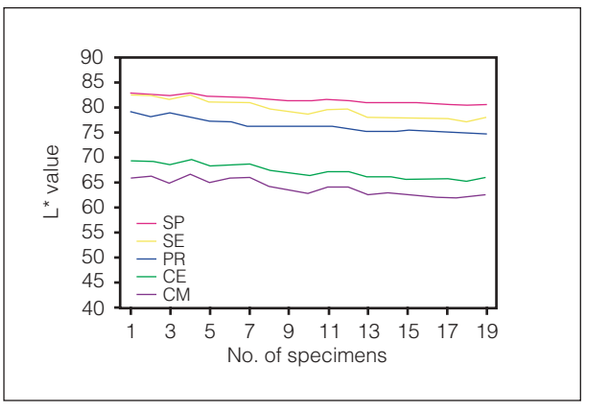
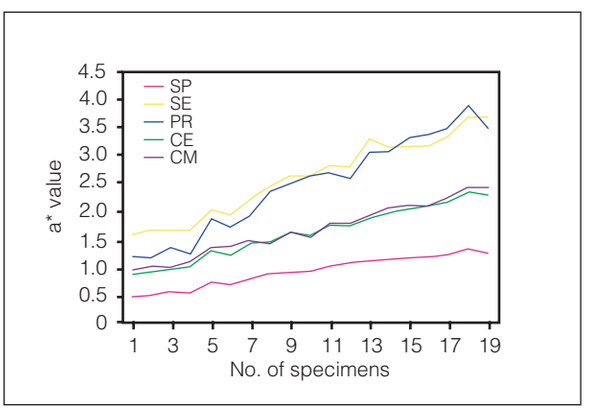
Fig 1 *(right)* Comparison of L* values from five instruments.

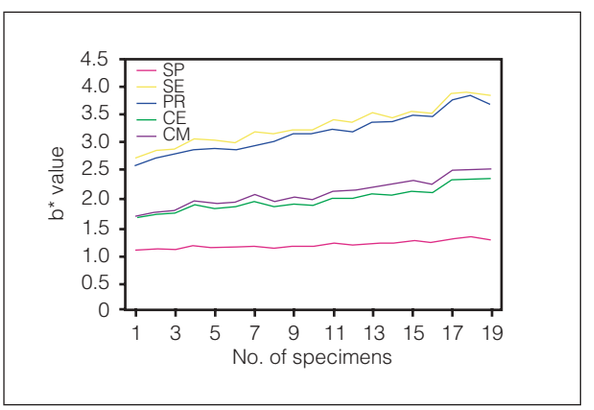
Fig 2 *(below)* Comparison of a* values from five instruments.

Fig 3 *(below right)* Comparison of b* values from five instruments.

Key:
SP = SP-1000
SE = ShadeEye NCC
PR = PR 650
CE = ColorEye 7000
CM = Chroma Meter







Conclusion: The color data for the same specimens measured on different instruments were correlated, although there were statistical differences among the data.

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