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EVALUATION OF DIFFERENT DEVICES FOR MEASURING PORK COLOR

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I. INTRODUCTION

Routine measurement of objective pork color in commercial slaughter plants is important for monitoring pork quality. Minolta instruments are considered the gold standard for color measurement [1]. However, the cost of the traditionally used Minolta instruments (CR-400 or CMD 700D) can be quite expensive. Thus, these instruments could be cost prohibitive in both small and large slaughter plants. Previous research has evaluated cost effective instruments designed for paint color assessment [1,2]. Predominantly, these studies have evaluated Nix Sensors, Spectro 1 Sensors, and the Color Muse colorimeter with mixed results. We are unaware of any research assessing the more cost effective Minolta CR-20 Color Reader for pork color which uses a different observer (10°) and only offers the D_{65} illuminant in comparison to the Minolta CR-400. The purpose of our research was to evaluate the NIX Spectro L (~$480 USD), the Spectro 1 Pro (~$300 USD), and the Minolta CR-20 (~$3200 USD) compared to the Minolta CR-400 (~$11,000 USD) to determine if these more cost effective instruments are viable for use in routine monitoring of pork color under commercial conditions.

II. MATERIALS AND METHODS

The CR-400 Chroma Meter (CR400; Konica Minolta, Ramsey, NJ, USA) was used as the base instrument to which all other color instruments were compared. The three instruments that were compared to the CR400 were the Nix Spectro L Spectrophotometer (NIX; Nix Sensor Ltd., Hamilton, ON, Canada), the Spectro 1 Pro SCI (SPC; Variable, Inc., Chattanooga, TN, USA), and the CR-20 Color Reader (CR20; Konica Minolta, Ramsey, NJ, USA). All instruments have an 8mm measurement aperture, except the NIX (16mm). All instruments used a 2° observer except the CR20 (10°). Comparisons of the CR400 with the NIX and SPC used the C illuminant, but the comparison between the CR400 and CR20 used the D_{65} illuminant.

Comparisons were made by using each instrument on the ventral surface of the boneless pork loin under commercial conditions (on the deboning line with moving belt) to determine CIE L*, a*, and b* values [3]. The NIX (n = 138), SPC (n = 120), and CR20 (n = 135) were each compared to the CR400 on different days and in three different commercial facilities. Each loin was scanned using the test instrument and then immediately scanned using the CR400 with care taken to ensure all measurements were in the same exact location of each loin.

Pearson's correlation coefficients were determined between the CR400 and the three instruments tested using the CORREL function of Microsoft Excel. The t-statistic was calculated from the correlation coefficients and significance levels of the correlations were determined using the T.DIST.2T function of Microsoft Excel. All correlations were significant ($P < 0.0001$). The slopes (x's from CR400; y's from the instrument of interest) were determined using the SLOPE function of Microsoft Excel. Bland-Altman plots [4] were used to generate bias (average of the difference between two instruments) and standard deviation (STD) of the individual differences.

III. RESULTS AND DISCUSSION

The CR20 had the strongest correlation with the CR400, followed by the SPC, and then the NIX for L* (Figure 1). The SPC had the slope closest to 1 followed by the CR20, and then the NIX for L*. All three instruments had a positive bias (average L* higher than the CR400) with the CR20 having the least amount of bias followed by the SPC, and then the NIX. The SPC had the strongest correlation for a*, followed by the CR20, and then the NIX. The SPC had the slope closest to 1 followed by the NIX, and then the CR20 for a*. The NIX had a positive bias (average a* higher than the CR400), but the SPC and CR20 had a negative bias (average a* lower than the CR400) with the SPC having the least amount of bias followed by the NIX, and then the CR20. The SPC had the strongest correlation for b*, followed by the CR20, and then the NIX. The CR20 had the slope closest to 1 followed by the SPC, and then the NIX. The NIX had a negative bias (average b* lower than the CR400), but the SPC and CR20 had a positive bias (average b* higher than the CR400) with the NIX having the least amount of bias followed by the SPC, and then the CR20.

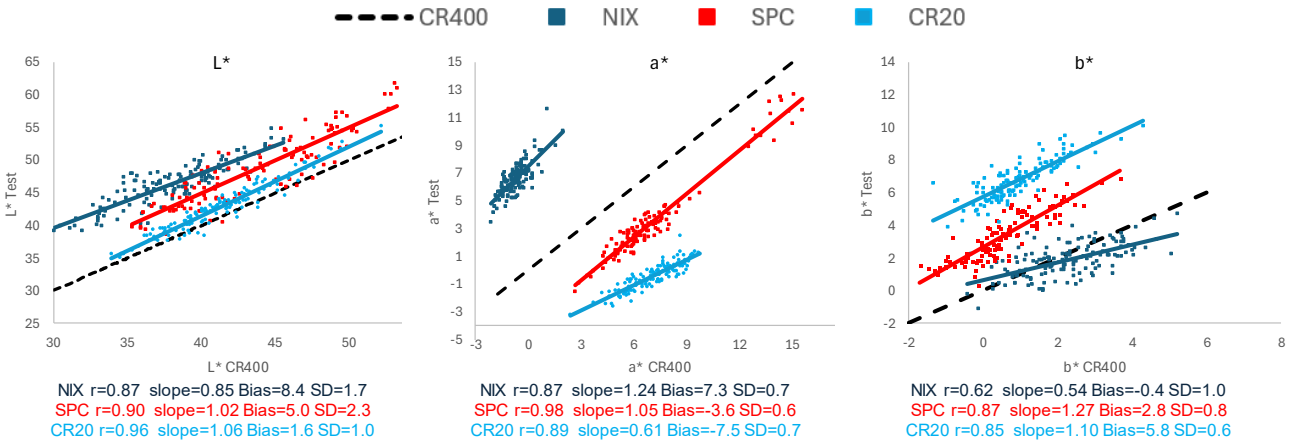


Figure 1. Comparison of the NIX, SPC, and CR20 to the CR400 on Pork Loin L*, a*, and b* Values

Ideally, when comparing an instrument to the current "gold standard" of the CR400 the correlation should be 1, with a slope of 1, and a bias of 0 in order for the instrument to be a perfect replacement. However, none of the three instruments would meet these criteria for L*, a*, and b*. The closest any instrument came to matching the CR400 was the CR20 with L*, but the CR20 had much higher biases for a* and b*. The SPC was best from the perspective that it was more consistent for L*, a*, and b* values. Wei et al. [1] reported that the SPC had lower correlations for a* (0.88) and b* (0.32), but in our data the correlation was higher for a* (0.98) and b* (0.87). The NIX was clearly the least comparable of the three instruments tested as it had the weakest correlations along with poorer slopes and biases for L*, a*, and b*. Previous reports [1] have indicated that these lower cost instruments have strong correlations with the Minolta instruments, but the absolute values are different, making it difficult to compare to other data taken with different instruments. Due to the strong correlations, these instruments would be valuable from the perspective that they are capable of detecting changes over time in internal benchmarking assessments or in detecting color differences between treatments.

Regarding the practicality of these instruments for use in a commercial environment, the CR20 was much more practical for use. The NIX instrument required a Wi-Fi connection for the instrument to measure, which may not be available in all commercial situations. The sampling time interval increased with the SPC during sampling sessions to the point of the sampling interval being > 20 sec which is not practical when taking measurements on-line in high-speed environments. The CR20 was a more practical option without the aforementioned limitations, but the CR20 does require calibrating each time the instrument is turned on.

IV. CONCLUSION

The NIX, SPC, and CR20 all correlated well compared to the CR400 for L*, a*, and b* although they each had biases that would prevent them from being compared on an absolute value basis. The SPC and CR20 closely aligned with the CR400, more so than the NIX. Each of these instruments are viable for use in internal benchmarking programs or in determining objective color differences between treatments. Although less expensive, the NIX and SPC have limitations in practicality (require Wi-Fi, speed of measurement, etc.) compared to the CR20 that may deem them unacceptable in some commercial situations.

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