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Estimation of Anthocyanin Concentration from Color Meter Measurements of Red Raspberry Fruit

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The color of red raspberry fruit (*Rubus idaeus* L.) is one of the most important characteristics in raspberry breeding. The appearance of the fruit is important for fresh-market uses, and the anthocyanin concentration is important for processed uses. Although extraction of anthocyanins from raspberry fruit is simple (Torre and Barritt, 1977), it is time-consuming and the process generates flammable and corrosive waste material. Subjective evaluations can be highly correlated with anthocyanin concentration, but it is difficult to obtain consistency in evaluations among samples and over time. A method is needed that would quickly quantify anthocyanins nondestructively without generating hazardous waste.

Color reflectance values have been related to subjective evaluations of color in fresh fruits and vegetables (Little, 1976; Setser, 1984). A previous study (Robbins and Moore, 1990) measuring anthocyanin changes during storage indicated that it may be possible to estimate anthocyanin concentration in raspberry samples using a color meter. However, that study used only four genotypes that were closely related. The objective of this study was to evaluate the possible use of a color meter to estimate the anthocyanin concentration of a diverse collection of red raspberry genotypes.

The color of red raspberry fruit was measured for 134 samples representing 46 clones. Clones were represented by three samples each, except for seven clones represented by two samples and one clone represented by six samples. Each sample consisted of five fruit. Fruit were harvested during the peak of the 1994 harvest season at Washington State Univ.'s Puyallup facility. Color was measured on the side of a slightly flattened whole fruit using a tristimulus color analyzer (Chroma Meter, model CR-200b; Minolta, Ramsey, N.J.) equipped with a measuring head with an 8-mm-diameter measuring area. The analyzer was calibrated to a standard white reflective plate (Y = 94.5, x = 0.3133, y = 0.3205) and used CIE (Commission Internationale de l'Eclairage) Illuminant C. Measurements were recorded in L*, a*, b* CIE coordinates. Chroma [$C^* = (a^{*2} + b^{*2})^{0.5}$], hue angle ($H = \arctan b^*/a^*$), and ratio of a* : b* (a*/b*) were calculated from a* and b*. The five fruit were stored at –20 °C as a single sample after color measurements were taken. Total anthocyanins were determined spectrophotometrically from acidified ethanol extracts from the frozen samples (Torre and Barritt, 1977) and expressed as cyanidin 3-galactoside. Regression equations were developed using color measurements to predict anthocyanin concentration.

All five measures of color were significantly correlated with the anthocyanin concentration, with r = –0.55, –0.56, –0.59, –0.65, and –0.72 for L*, a*, C*, b*, and H, respectively. In scatter plots of anthocyanin concentration and each of the measures of color, there was no evidence of an area of confusion as reported for some scales with dark-colored juices (Eagerman et al., 1973). Correlation coefficients were calculated between combinations of the five measures of color with the anthocyanin concentration. The highest correlation coefficient was for a*/b* with r = 0.73. The best simple linear regression equation used a*/b* with r^2 = 0.53 (Fig. 1). The five color measurements were all positively correlated with each other and all were negatively correlated with a*/b*. Because of the high level of intercorrelation, addition of more variables did not greatly improve the model, with a model with all six variables having R^2 = 0.58. H and a*/b* are highly related (r = –0.988) and, in samples from other raspberry clones in another study, the correlation coefficient between H and anthocyanin concentration was slightly higher than that for a*/b* (data not shown).

The results of this study were similar to those reported for changes in color during storage for four raspberry cultivars (Robbins and Moore, 1990). However, in this study the r^2 was smaller than in the storage study. The current study used many more raspberry clones with a diverse genetic background. None of the four cultivars used in the storage study had significant levels of a "bloom" on the fruit, while in this larger study, bloom was present on fruit of some clones. The presence of bloom would increase the L*, a*, and b* values compared to fruit with the same anthocyanin level without bloom.

Although raspberry fruit are not ideal samples for color measurement, as delineated by Hunter and Christie (1978), a color meter adequately approximated the anthocyanin concentration of red raspberry fruit quickly and nondestructively. It may be sufficiently accurate for screening populations and could be used in the field. Hue angle and a*/b* were the best predictors of anthocyanin concentration for red raspberry fruit.

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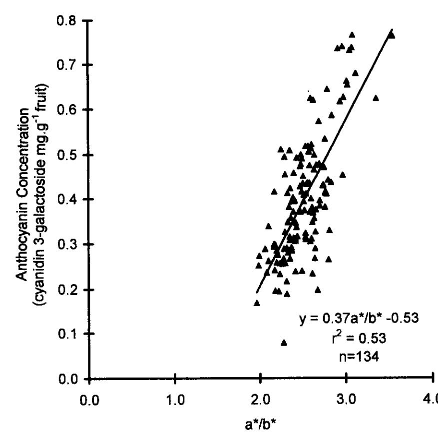

Fig. 1. Relationship between a*/b* measured on fresh raspberry fruit and anthocyanin concentration.