Quantifying Raspberry Color Using Image Analysis

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INTRODUCTION

Raspberry production is a significant component of Washington State's agricultural industry. Raspberries make up a 1-billion-dollar market in the United States and Washington comprises 40% of that market. Recently, foreign imports have been on the rise, with growing industries in Serbia, Mexico and Chile all competing with Washington growers. This has made it important to give Washington growers more tools to remain competitive in this global market.

To remain viable, it is important to provide growers with the most competitive cultivars possible. To do this, it is necessary to compare cultivars to accepted industry standards in appearance, flavor and machine harvestability. 'Meeker', 'WakeField' and 'WakeHaven' are all commonly grown cultivars and have been sold for their attractive color for processing. The color of raspberry genotypes is currently judged subjectively by sight and is not standardized. In order to compare new breeding selections effectively to accepted cultivars, it is important to have a consistent and accurate method for characterizing color.

OBJECTIVES

The main goal of this project is to provide a method for accurately describing the color of raspberries for use in the United States market. Within this goal are three major objectives:

- Identify and develop a reference for raspberry color that is accepted by the industry as a desirable color for processing.
- Create a tool to accurately image raspberries so that results are not variable due to lighting conditions or shadows/reflectiveness.
- Develop an algorithm to identify berries and extract average red, green and blue (RGB) values. The program should be consistent and accurate.

MATERIALS & METHODS

Figure 1. Collection of raspberries from the Oxbo 9140 July 2022.

Sampling

- Eight genotypes of raspberry were sampled from an Oxbo 9140 raspberry harvester (**Fig. 1**).
- Raspberries were stored in a refrigerator overnight (1°C).
- The next morning 50 raspberries per genotype were imaged using the phenotyping box (**Figs. 2-3**).
- Raspberries were placed on freezing trays stored at -1 °C for 72 h.
- Frozen raspberries were re-imaged.

Analysis

- Eight images were taken of each genotype with the last image of each series run through the MATLAB algorithm.
- The algorithm identified the number of berries and extracted RGB values from each berry, storing these values in a table and outputting to an excel file.
- Data were analyzed using RStudio. Analysis of variance and Tukey HSD test were performed with α = 0.05.

Figure 2. Samples were imaged inside the phenotyping box.

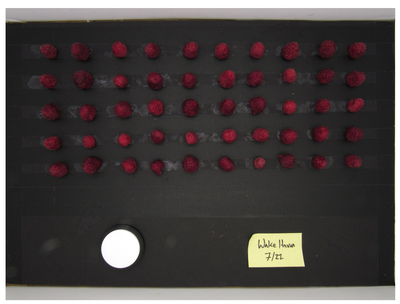

Figure 3. Samples were imaged after overnight cold storage. A reference panel was placed for calibration.

RESULTS

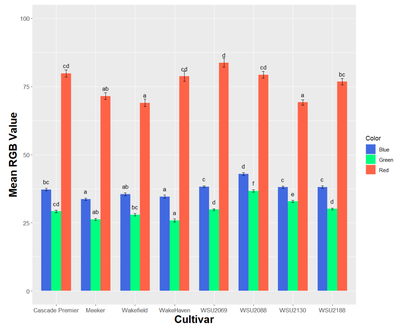

Figure 4. Mean RGB values for each of the eight genotypes of fresh raspberry after cold storage. Means with the same letter within a RGB channel are not different by genotype (α = 0.05). Bars represent standard error (n=50 berries/genotype).

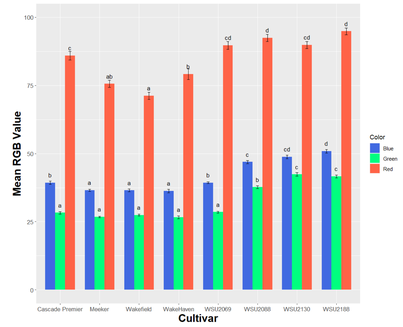

Figure 5. Mean RGB values for each of the eight genotypes of frozen raspberry. Means with the same letter within a RGB channel are not different by genotype (α = 0.05). Bars represent standard error (n=50 berries/genotype).

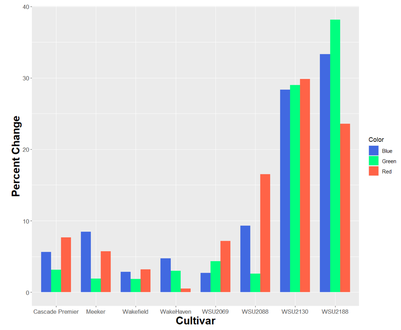

Figure 6. Percent change (%) in RGB values across eight cultivars between fresh and frozen raspberries.

- Raspberry color had different RGB values across genotypes with 'Meeker', 'WakeField' and 'WakeHaven' being similar in color in the fresh and frozen (**Figs. 4-6**).
- All four WSU selections and 'Cascade Premier' showed variation in RGB values from the three controls.
- Percent change in RGB values in WSU2130 and WSU2188 was greater between frozen and unfrozen berries (**Fig. 6**).
- Visual color variation was minor (**Figs. 7-8**), but the variation of RGB values can be significant across genotypes (**Figs. 4-5**) and between unfrozen and frozen berries.

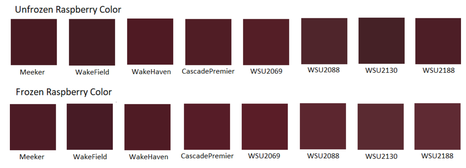

Figure 7. Mean RGB values were used to create the mean color of each fresh and frozen genotype.

Figure 8. A row of unfrozen berries from all eight genotypes. 1='Meeker', 2='WakeField'. 3='WakeHaven', 4='Cascade Premier', 5=WSU2069, 6=WSU2088, 7=WSU2130, and 8=WSU2188.

DISCUSSION & CONCLUSIONS

Finding exact color values gives us a method to assess changes towards a desired color. This makes color analysis a useful tool for breeding where changes are incremental and color changes can be very small.

Considerations

- Frost deposited on WSU2130 (**Fig. 9**) and WSU2188 in the freezer may have affected the color values. This could be counteracted if a cover was applied.
- Future research could explore other color models such as HSV or L*a*b and determine if they more accurately describe color.
- Looking at variance in color within each berry could be a useful tool in judging color uniformity and commercial acceptability.

Figure 9. Frozen sample of WSU2130 that had noticeable frost on berries.

Main Take-Aways

- Successfully extracted RGB values and compared new genotypes to industry standard cultivars.
- New cultivars and selections are not yet within the range of industry standards.
- The raspberry industry is changing, and it is important to accurately assess new selections and cultivars for competitiveness on the market.

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