Evaluation of Trait Changes Across Three Consecutive Weeks of Harvest in the WSU Apple Breeding Program Phase 2 Accessions

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Introduction

- The Washington State University Apple Breeding Program (WABP) is comprised of a seedling phase and three phases of selection, with a large portion of data collection completed in Phase 2.
- Harvest date is determined for each Phase 2 accession using change in background color and the destructive measure of starch index rating of 4.5, with each accession harvested over three consecutive weekly picks to ensure optimal maturity is not missed.
- The number of fruit available is limited because each Phase 2 accession is made up of only five replicate trees.
- As fruit ripens starch is converted to sugars (Fig. 1), chlorophyll degrades, soluble solids content (SSC) increases, while titratable acidity (TA) and firmness decrease.
- The Delta Absorbance (DA) meter is a non-destructive device that measures the Index of Absorbance Difference (I_{AD}; Fig. 2 and 3), a simplified measure of chlorophyll in the outer layer of an apple (1,7).
- The I_{AD} has been shown to correlate with starch degradation, SSC, TA, and firmness (2,3,4,5,6).

No starch converted to sugars → All starch converted to sugars

Figure 1. Iodine stains the starch to show different maturities of apples

670 nm: near chlorophyll-a absorption region
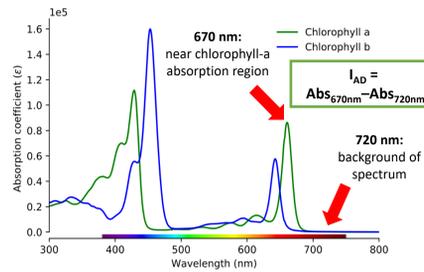720 nm: background of spectrum

$$I_{AD} = Abs_{670nm} - Abs_{720nm}$$

Figure 2. The visible-near infrared spectrum. The I_{AD} is calculated by $Abs_{670nm} - Abs_{720nm}$, near the chlorophyll-a absorption region.

Objectives

1. Identify changes in maturity and quality traits across three consecutive weekly picks
2. Compare differences in maturity and quality traits between 2021 and 2022

Materials and Methods

Figure 3. The DA meter

Figure 4. The DA meter measures the **Index of Absorbance Difference (I_{AD})**, which indicates the chlorophyll content in the outer layer of the apple

Figure 5. Using DA meter in the field to determine I_{AD}

- In 2021 and 2022, the WABP determined the harvest date for Phase 2 accessions using a starch index rating, supplemented with the I_{AD}. For this project, data from four accessions (312, 344, 349, and 376) grown at the same site were selected for comparison between the two years.
- A five-fruit sample from each accession was collected with a target I_{AD} value of $I_{AD} \pm 0.1$, decreasing by 0.1 for each consecutive weekly pick (Fig. 5). I_{AD} values were collected again once the fruit was back at the lab (I_{AD} at-harvest; Fig. 4).
- Samples were stored at 4°C for two months, then moved to room temperature for 7 days and evaluated using non-destructive (I_{AD} after storage) and destructive trait measures (starch index rating, SSC, TA, and firmness).
- Averages and standard errors were calculated for all traits within each five-fruit sample for each accession.
- Tukey's Honestly Significant Difference (HSD) test was used to identify significant differences between picks within each accession.
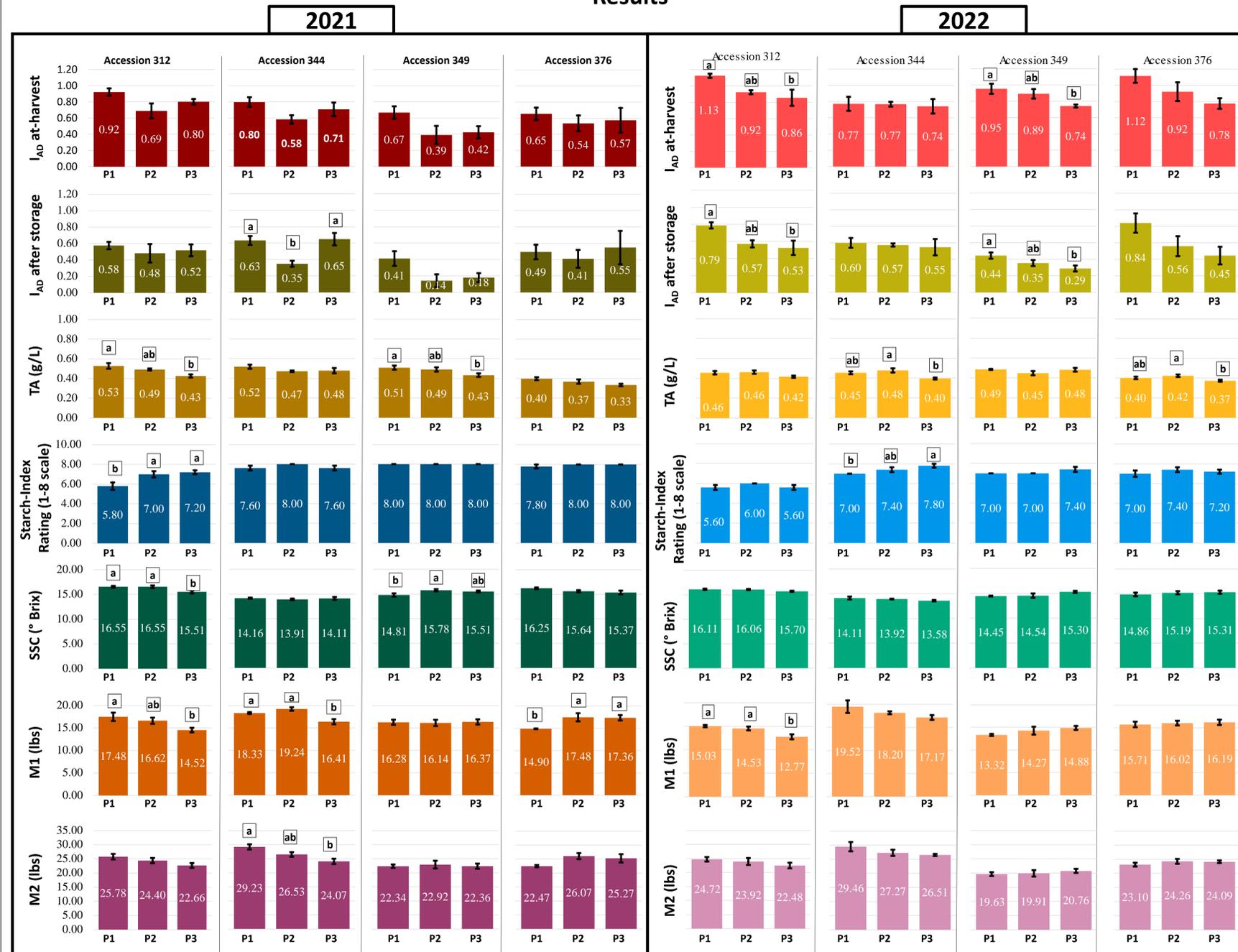
Results

Figure 6. I_{AD} at harvest and I_{AD}, TA, starch-index rating, SSC, M1, and M2 after storage of four WABP Phase 2 accessions. Averages and standard errors were calculated from a five-fruit sample from each weekly pick for each accession in 2021 and 2022. Significant differences between means determined by Tukey's HSD test are indicated by the letters a, b, ab. Means followed by the same letter are not statistically different at P<0.05.

Results

- In 2021, across the three weekly picks, starch index rating increased in two accessions (312 and 376), TA (312, 344, and 376) M1 (312), M2 (312 and 344) decreased, but I_{AD} at-harvest and after storage were variable.
- In 2022, across the three picks, SSC, M1, and M2 decreased in accessions 312 and 344, while they increased in accessions 349 and 376. Starch value increased in accession 344 and TA was variable. Additionally, in all accessions, the I_{AD} values at-harvest and after storage decreased.

Conclusions

- All four accessions behaved differently, which is not surprising, as they are all genetically unique. In addition, maturity is likely influenced by factors such as crop load and environmental conditions (temperature, water, and wind).
- Consistencies observed across picks after storage indicate a longer harvest window may be possible for specific accessions. A longer harvest window would enable a grower to more efficiently manage their harvest crew, which is useful when growing multiple varieties.
- The research completed in this project highlights the need for multi-year evaluations to fully determine trait differences across years.

Sources

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