FINAL PROJECT REPORT

Project Title: Optimizing harvest time for WA38

Project Award: AP-19-105B

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Cooperators: Ryan Sheick, Ines Hanrahan, Stemilt Growers (Quincy)

Other funding sources:
Stemilt Growers (Quincy) orchard

Total Project Funding: $95,419

WTFRC Budget:
Organization Name: WTFRC **Contract Administrator:** Kathy Coffey
Telephone: (509) 665-8271, ext. 2 **Email:** kathy@treefruitresearch.com

WFTRC	2019
Salaries[1] (include benefits)	$ 8,140
Wages[2]	$ 14,188
Benefits[3]	$ 7,565
Supplies	$ 1,500
Travel	$ 1,000
total	$ 32,393

[1]Salary and benefits for Manoella Mendoza and Tory Schmidt.
[2]Wages and [3]benefits for hourly employees.

Budget

Organization name: WSU **Contract Administrator:** Katy Roberts/Shelli Tompkins
Telephone: 509-293-8803 **Email address**: arcgrants@wsu.edu/ shelli.tompkins@wsu.edu

Musacchi-Serra-Ross	**2019**
Salaries[1]	**$ 28,800**
Benefit[2]	**$ 11,226**
Plot fee[3]	**$ 3,000**
Sensory evaluation[4]	**$ 9,000**
Supplies[5]	**$ 8,000**
Travel[6]	**$ 3,000**
total	**$ 63,026**

Footnotes:

[1] Salary for 60% Research assistant ($4000/month) (Musacchi-Serra)

[2] Benefit on salary at 38.98%

[3] Plot fee for plots

[4] Sensory evaluation Ross lab.

[5] Labware/consumable, fruit sample reimbursement (Musacchi)

[6] 5,556 miles/year for domestic travel (0.54$/mile) to go to the orchard.

RECAP OBJECTIVES:

1. Determine optimum timing for WA38 harvest based on fruit production, pack out, and quality.
2. Validate the new WA38 starch scale as a tool to predict harvest time.
3. Assess consumers' acceptance of WA38 fruit harvested at a different time (6 consecutively weekly picks[¥]).

[¥] *From the original project submitted and funded, the number of picks to study increased from 4 to 6 picks for 6 weeks in a row. No budget modification was requested.*

SIGNIFICANT FINDINGS:

- The time of harvest impacted the pack-out: cull fruit/tree increased significantly from Pick3 to Pick6, and consequently, the amount of "good" fruit/tree decreased.
- With the latest pick, a significant increase of average fruit dropped per tree was noticed: about 1.7 Mton/Acre (4.4 bins/A) production could be lost if the harvest date is delayed to the third week of October (Pick6), while at Pick1 the lost yield was only 0.5 Mton/A (1.3 bins/A).
- The delay in harvesting is influencing the grading quality of fruit: early harvest date (Pick1) had the lowest percentage of cull fruit (8.2%) versus 34% six weeks later (Pick6).
- More delayed was the harvest date, higher was the incidence of defects like bird peck and split (Pick6: 27% of cull for bird peck and 40% cull for split).
- An increase of greasiness has been observed in the late picks. Pick3 showed 3.1% of the fruit affected, while Pick4 reach 10.9%. At Pick5, the percentage of fruit affected increase to 18.8%.
- Apple flavor at harvest showed a higher incidence of starchy/unripe flavor in Pick1 apples than in all the other 5 picks, while from Pick2, 80% of the tasted apples showed a ripe/good flavor.
- Parameters correlating the most with starch index were firmness and I_{AD} both at T0 and T1 quality assessment. I_{AD} drop from 0.73 (September 17th) of the first pick to 0.40 of the fourth pick (October 8th). In many varieties, an I_{AD} below 0.4 can be considered a threshold for harvest.
- Non-destructive estimation of dry matter and soluble solids did not increase with later pick dates, suggesting no benefit to internal fruit properties with longer on-tree time.
- However, later picks did improve coloring, which is a known factor in determining consumer purchasing behavior, though also at the risk of increasing proportions of culled fruit.
- A threshold of consumer liking was identified between pick 1 and 2, indicating starch levels of 2.2 or greater are necessary to achieve the most positive consumer outcomes.

METHODS

Objective 1) Determine optimum timing for WA38 harvest based on fruit production, pack out, and quality.

Within WA38 P3 block in Quincy (trees planted in 2008 and grafted on M9-337, 12 ft x 3 ft, 1210 trees/Acre, and 1360 ft of elevation), in August 2019, we selected 48 trees for this trial. Trees had similar TCSA (average 43.5 cm^2) with a number of fruits per tree ranging from 93 to 175 apples per tree. Eight trees per each pick have been utilized to represent the crop load variability in the field. For each of the 6 harvests (picks), we randomly choose 8 trees available as repetitions. WA38 apple's internal quality varies depending on the date of harvest. Little is known about the optimum picking date and how to monitor the fruit once received at the storage facility. We harvested weekly for 6 weeks. For each pick, WA38 apples were sampled to understand the variation of internal fruit quality based on the harvest dates. Fruits were collected for quality analysis at harvest and one month after harvest (precisely 30 days in cold storage RA after each of the picks) as well as at the beginning of December 2019 (when fruit started to be sold in the retail stores for the first time in WA38's history).

The first harvest was planned at an average of starch index ≈ 1.4. That date set the beginning of the entire experiment. Here the dates of harvest in blk P3 and the corresponding average of the starch index based on the WA38 T0 quality run immediately after harvest.

Pick	Harvest dates	Starch index (1-6)
Pick1	09/17/2019	1.4
Pick2	09/24/2019	2.2
Pick3	10/01/2019	3.3
Pick4	10/08/2019	3.3
Pick5	10/15/2019	3.4
Pick6	10/22/2019	4.9

The following parameters were collected for each pick:

- Yield (kg/tree as net weight)
- Number of total fruits harvested from the tree
- Number of dropped fruit and their weight
- Size of all fruit/tree in mm (sizer 65 to 110 mm)
- Good (extra fancy and fancy) vs. cull fruit count (pack out by pick) and cull reasons.

Objective 2) Validate the new WA38 starch scale as a tool to predict harvest time.

A set of 16 apples/pick/month was assigned to a monthly "starch degradation" assessment for 5 months until March 2019 to understand the evolution of starch index in storage.

Objective 3) Assess consumers' acceptance of WA38 fruit harvested at a different time (6 consecutive weekly picks).

Fruit from the samples previously described were provided to Dr. Ross's lab at the WSU Sensory Evaluation Facility end of November 2019. Fruits from regular cold storage were brought up to room temperature 24 hours before analysis. Apples were evaluated by consumers (80-120) using a ballot where preferences about different apple attributes were scored with a 1 to 9 hedonic scale. Consumers were asked to express their preference for apple firmness, crunchiness, juiciness, sweetness, flavor, overall liking. The sensorial analysis was performed in two parts: on December 3rd, 2019, for shelf-life 1 day and December 10th, 2019, for shelf-life 7 days (apples were kept at room temperature for 7 days).

RESULTS & DISCUSSION:

Objective 1) Determine optimum timing for WA38 harvest based on fruit production, pack out, and quality.

As expected, yield data in 2019 did not reveal differences in kg/tree between picking times (trees have the same crop load level), but significant differences in average fruit weights of apples harvested at Pick6 and Pick1; with 47 grams more per fruit on average with the latest pick (Table 1).

*Table 1: WA38 harvest data for 2019 in block P3 Quincy by picking dates from September 17th to October 22nd. Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

PICK	date	N=	August 2019 TCSA (cm^2)	Crop Load (n frt/TCSA)	tot num frt/tree	yield 2019 (kg/tree)	avr apple weight (g)		% cull from n frt		% good from n frt		I_{AD} (10 apples/tree)		bins/A (1 bin=880lb)	Mton/A
1	9.17.19	8	45.1	3.2	139	28.6	206	b	8.2	c	91.8	a	0.73	a	86.8	34.7
2	9.24.19	8	44.2	2.9	125	27.0	219	ab	12.5	c	87.5	a	0.62	ab	81.9	32.7
3	10.1.19	8	43.7	3.1	134	30.3	226	ab	11.7	c	88.3	a	0.48	bc	91.7	36.6
4	10.8.19	8	43.2	3.4	145	32.6	225	ab	16.5	bc	83.5	ab	0.40	cd	98.8	39.5
5	10.15.19	8	42.6	3.1	129	30.9	239	a	23.9	ab	76.1	bc	0.31	d	93.8	37.4
6	10.22.19	8	42.3	2.9	120	28.5	243	a	33.4	a	66.6	c	0.28	d	86.4	34.5
Significance			NS	NS	NS	NS	**		***		***		***		NS	NS

The time of harvest impacted the pack out of the fruit: kg of cull fruit increased significantly from Pick3 to Pick6, and consequently, the amount of "good" fruit/tree decreased (presented as % in

Table 1). I_{AD} index measured at harvest showed a consistent decrease with the delay of harvest and a significant drop from Pick3 to Pick6.

The size of WA38 fruit improved significantly more delayed was the pick (Figure 1); indeed, Pick6 had 21.8% more fruit belonging to the size 64 apples/box (=85 mm) than Pick1 (with only 4.7%). Pick3 and 4 showed a similar fruit size distribution; starting from Pick3, there was only 16% of apples in the sizes below or equal to 70 mm (=113 apples/box) with 80-72 apples/box (80 mm) being the most representative sizes (Figure 1).

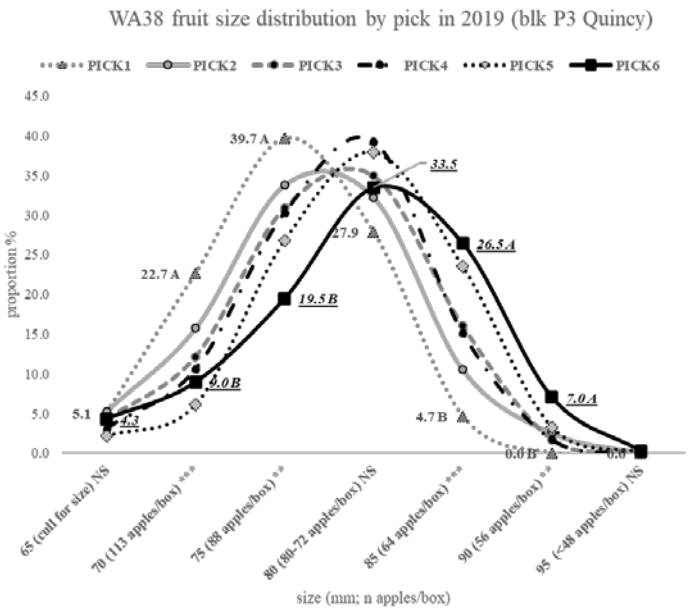

Figure 1: WA38 fruit size distribution by pick in 2019. Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.

The fruit grading carried out at each harvest showed significant differences in pack-out (Figure 2). Pick1 had the lowest percentage of cull fruit (8.2%) versus a 34% six weeks later (Pick6); from Pick4, the number of cull apples increased to 16.5%, statistically similar to Pick5 with 24%. The proportion of extra fancy (XF) apples was the highest at Pick1 with 73.8%, while at Pick6, they were representing only 39.3% of the harvested fruit. The delay in harvesting is influencing the grading quality of fruit (Figure 2). Among all the possible reasons to cull the fruit, we observed that later was the harvest date higher was the incidence of defects like bird peck and split (data not shown). The split was reason to cull apples for the 4% at Pick1 while, 6 weeks later, the proportion got tenfold (40% culled for the split, mainly stem split); after Pick4, the split incidence reached worrisome levels (data not shown).

The color was always at the highest level (50 to 100% red colored surface) since Pick1 to Pick6, ranging from 94% to 100% (data not shown). Green spot did not significantly affect this production, reaching a maximum of only 4.4% at Pick2, while all the other harvest dates were affected at lower incidence (data not shown).

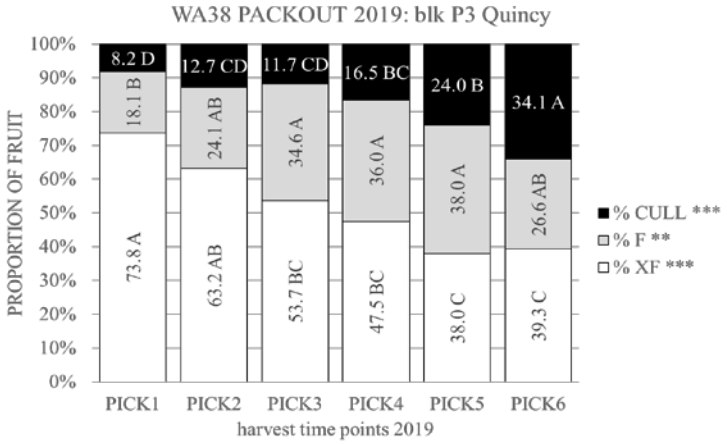

Figure 2: WA38 fruit grading and pack-out2019 by pick: XF= extra fancy apples, F=fancy, CULL=cull.
*Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

Instrumental fruit quality assessment at each time of picking (T0=24h after harvest) revealed differences in apple physiology/quality related to delay in the harvest (Table 2). The starch index increased significantly from Pick1 to Pick6 (1.4 to 4.9 respectively on a 1-6 scale), showing starch degradation of 0.8-0.9/week for the first 2 picks. From Pick 3 to Pick5, the index did not drop, probably due to the critical decrease in temperature registered in October 2019 in the Wenatchee/Quincy area. Pick3 registered an average starch index around 3.3 (across 80 apples), a value already higher than the recommended 2.5, while Pick2 was 2.2, so closer to the recommended values to star WA38 harvest. A significant drop of the I_{AD} (index of

absorbance difference measured by the DA meter) was noticed between Pick2 and Pick3, reflecting decreased firmness (from 19.4 lb to 17.9 lb, Table 2). Soluble solids instead increased significantly only at Pick4, reaching 12.2 ° Brix. At the same time, titratable acidity (TA) showed similar values from Pick2 to Pick5 (0.56 to 0.55%), with a spike at Pick6 challenging to explain (Table 2).

Same instrumental quality analyses were done precisely 30 days after each of the 6 harvest dates to see how the quality changed after one month of regular air storage at 34°F. For Pick1, firmness

Table 2: WA38 quality at harvest 2019 (T0) by picking dates from September 17th to October 22nd.
*Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

pick	time	rep =trees (10apples/ tree)	Starch index (1-6)	Avr frt weight (grams)	Red color (1-4)	Backgr. Color (0.5-6.0)	Red intensity (1-5)	I_{AD} index	Firmness (lb.)	Soluble solids (SSC, %brix)	TA (% malic ac.)
PICK1	T0	8 (10)	1.4 D	210 B	3.9	5.8	4.6	0.73 A	20.0 A	11.1 C	0.80 A
PICK2	T0	8 (10)	2.2 C	215 AB	3.8	5.5	4.2	0.65 A	19.4 A	11.2 C	0.56 C
PICK3	T0	8 (10)	3.3 B	228 AB	4.0	5.7	4.5	0.48 B	17.9 B	11.7 BC	0.52 C
PICK4	T0	8 (10)	3.3 B	224 AB	4.0	5.8	4.7	0.40 BC	16.8 C	11.6 BC	0.58 C
PICK5	T0	8 (10)	3.4 B	245 A	4.0	5.8	4.8	0.31 C	16.9 C	12.2 A	0.55 C
PICK6	T0	8 (10)	4.9 A	240 AB	4.0	5.7	4.6	0.28 C	16.7 C	12.1 AB	0.72 B
Significance			***	*	NS	NS	NS	***	***	***	***

decreased significantly by about 0.88 lb from T0 to T1, but no other significant differences were seen in the comparisons between T0 and T1 within each picking dates (data not shown). At T1 (+30d), the starch index was already mostly degraded and on average above 5 from Pick4 to Pick6. SSC showed an increase between T0 and T1 only at Pick1 and Pick4, while titratable acidity reported higher values at T1 (+30d) than at T0 for Pick 1, 3, 4, and 5 (data not shown).

In general, non-significant correlations were reported between the starch index and titratable acidity at T0 and T1. Non-destructive dry matter (DM %) predicted by Felix F750 at harvest showed that the DM did not significantly change, keeping the fruit on trees for 6 weeks longer. Values were ranging on average from 13.9% to 14.4% across the 6 picks (NS). No significant differences after 30d of storage emerged in the dry matter across the 6 picks (data not shown).

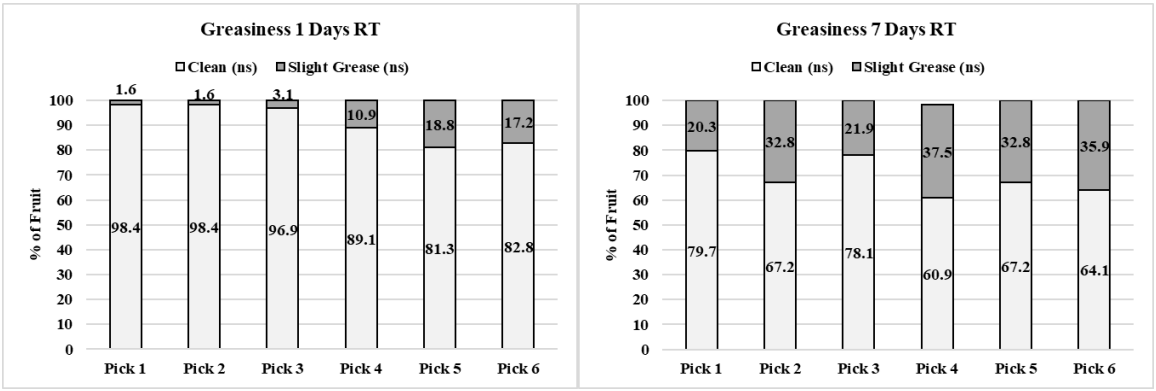

Figure 3: WA38 greasiness assessment at the industry selling time (T2) plus 1 (left) or 7 (right) days of room temperature ripening by picking dates from September 17th to October 22nd.

After storage (T2) and with 1 day of room temperature ripening, the proportion of fruit considered clean and grease-free appeared on average to be greatest in early pick dates (Pick1 through 3, > 95% of fruit considered "clean"). However, overall, differences in picks were not significant. Similarly, the average proportion of apples with some degree of greasiness (slight grease) was higher in later picks (Pick5 and Pick6, > 15% of fruit considered to have "sight grease"), though again, these trends were not statistically significant (Figure 3). After 7 days of room temperature ripening, fruit from

all picks appeared relatively similar in terms of greasiness, though Pick1 displayed the greatest proportion of clean fruits (Figure 3).

Within each given pick date, the average proportion of fruit displaying slight greasiness increased significantly from 1 to 7 days of room temperature ripening except for pick 5 where the increase from 18.8 to 32.8% of fruit displaying slight grease was not determined to be significantly different (Figure 3).

Non-destructive assessment of dry matter and soluble solids revealed no significant differences among pick dates at both 1 and 7 days of room temperature ripening at the industry selling time (T2). While some differences were apparent at harvest, it appears that starch conversion during storage may have had a homogenizing effect on fruit, leading to largely similar values of predicted dry matter and SSC at T2 (Figure 4).

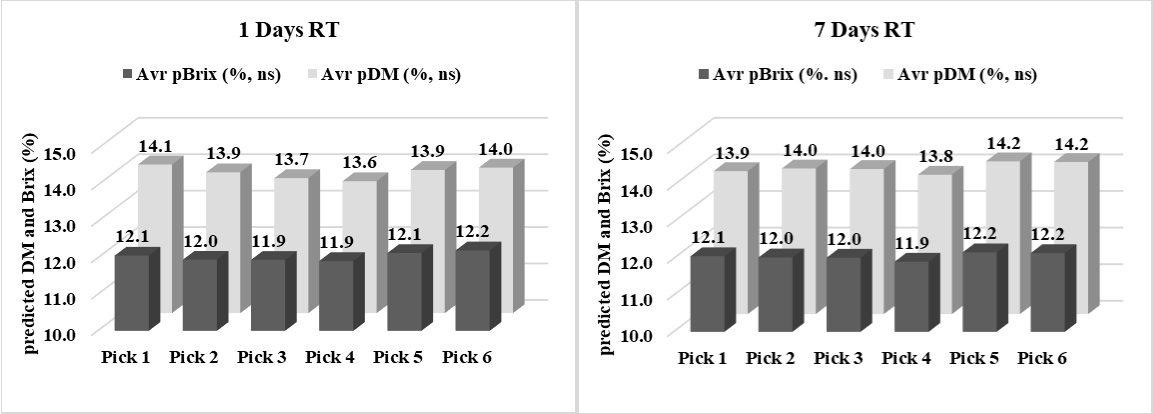

Figure 4: WA38 non-destructive dry matter and soluble solids assessment at the industry selling time (T2) plus 1 or 7 Days of room temperature ripening by picking dates from September 17th to October 22nd.

On average, predicted dry matter was slightly higher in fruit at T2-7 days than T2-1 day of room temperature ripening, likely due to loss of water content during this time. However, this difference was not significant for any pick date. Meanwhile, predicted sugar content remained similar on day 7 compared to day 1 (Figure 4).

At industry selling times (T2, December 2019), starch differences among pick dates were subtle but significant and reflected the patterns as seen at-harvest (i.e., Pick1 and Pick2 had the lowest levels of the starch index, Pick5 and Pick6 had the highest), indicating more conversion to sugar in later picking dates (Table 3). However, this did not translate to meaningful patterns in soluble solids content, though significant differences were present. After 7 days of room temperature ripening, no significant differences in soluble solids were detectable. However, fruit color was often significantly greater in later pick dates relative to early pick dates in terms of the amount and intensity of red color and the amount of background color. After 7 days of ripening, firmness was significantly higher in early pick dates relative to later picking dates (Table 3).

*Table 3: WA38 quality at the industry selling time (T2) among picking dates from September 17th to October 22nd plus 1 or 7 Days of room temperature ripening. Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

Pick	Ripening Period	rep=trees(8 apples/tree)	Starch Index (1-6)	Avr Fruit Weight (g)	Red Color (1-4)	Backgr. Color (0.5-6.0)	Red Intensity (1-5)	I_{AD} (DA Index)	Firmness (lb)	Soluble Solids (SSC %Brix)	TA (% malic acid)
Pick 1	1 days RT	8 (8)	5.4 b	207	3.9	5.6	4.2	0.36	17.8	12.0	0.68 a
	7 days RT	8 (8)	5.9 a	207	4.0	5.7	4.1	0.26	17.5	12.3	0.50 b
		Significance	***	ns	ns	ns	ns	ns	ns	ns	***
Pick 2	1 days RT	8 (8)	5.4 b	212	4.0	5.7	4.7	0.39	17.1	11.4 b	0.68 a
	7 days RT	8 (8)	5.8 a	209	4.0	5.8	4.5	0.30	17.0	12.7 a	0.52 b
		Significance	**	ns	ns	ns	ns	ns	ns	**	**
Pick 3	1 days RT	8 (8)	5.5 b	228	4.0	5.8	4.8	0.36 a	17.1 a	11.2 b	0.67 a
	7 days RT	8 (8)	5.9 a	217	4.0	5.9	4.8	0.29 b	16.6 b	12.5 a	0.50 b
		Significance	***	ns	ns	ns	ns	***	*	***	***
Pick 4	1 days RT	8 (8)	5.7 b	223	4.0	5.9	4.9	0.32	16.9 a	11.3 b	0.65 a
	7 days RT	8 (8)	5.9 a	221	4.0	6.0	4.9	0.28	16.2 b	12.6 a	0.49 b
		Significance	**	ns	ns	ns	ns	ns	**	***	***
Pick 5	1 days RT	8 (8)	6.0	233	4.0	5.9	4.8	0.26	17.3	11.8 b	0.71 a
	7 days RT	8 (8)	6.0	223	4.0	5.9	4.7	0.22	16.9	12.9 a	0.53 b
		Significance	ns	ns	ns	ns	ns	ns	ns	*	***
Pick 6	1 days RT	8 (8)	5.9	249	4.0	5.9	4.7	0.26	16.9	12.0 b	0.70 a
	7 days RT	8 (8)	6.0	237	4.0	5.9	4.8	0.24	16.9	13.0 a	0.49 b
		Significance	ns	ns	ns	ns	ns	ns	ns	**	***

Comparing quality within each pick date, we see significant increases in starch index between 1 and 7 days of room-temperature ripening in Picks1-4, indicating further conversion of starch to sugars as the fruit ripens at room temperature (Table 3). No further change in the starch index was detected in Picks5 and 6, suggesting no further evolution of these fruits was possible as measured via starch index. However, significant increases in sugars were present for most picks and even in Picks5 and 6 despite no starch index changes. This would suggest that more starch was present in these fruits and available for sugar conversion than was detectable at the starch index level. As is typical, firmness decreased as fruits remained at room temperature though this decrease was only significant in Pick3 and Pick4. In terms of titratable acidity, the percent of malic acid in fruits decreases significantly from 1 to 7 days for all picks. No significant changes were found in fruit appearance or the I_{AD} index for most picks except Pick3, which showed a slight, though significant, drop in I_{AD} (Table 3).

Objective 2) Validate the new WA38 starch scale as a tool to predict harvest time.

Starch levels in the first two months after harvest reflected differences at-harvest (i.e., Pick1 had lowest, Pick6 had highest). After two months of storage, all apples, regardless of pick, had roughly the same starch, indicating a homogenization of fruit during storage (Figure 5).

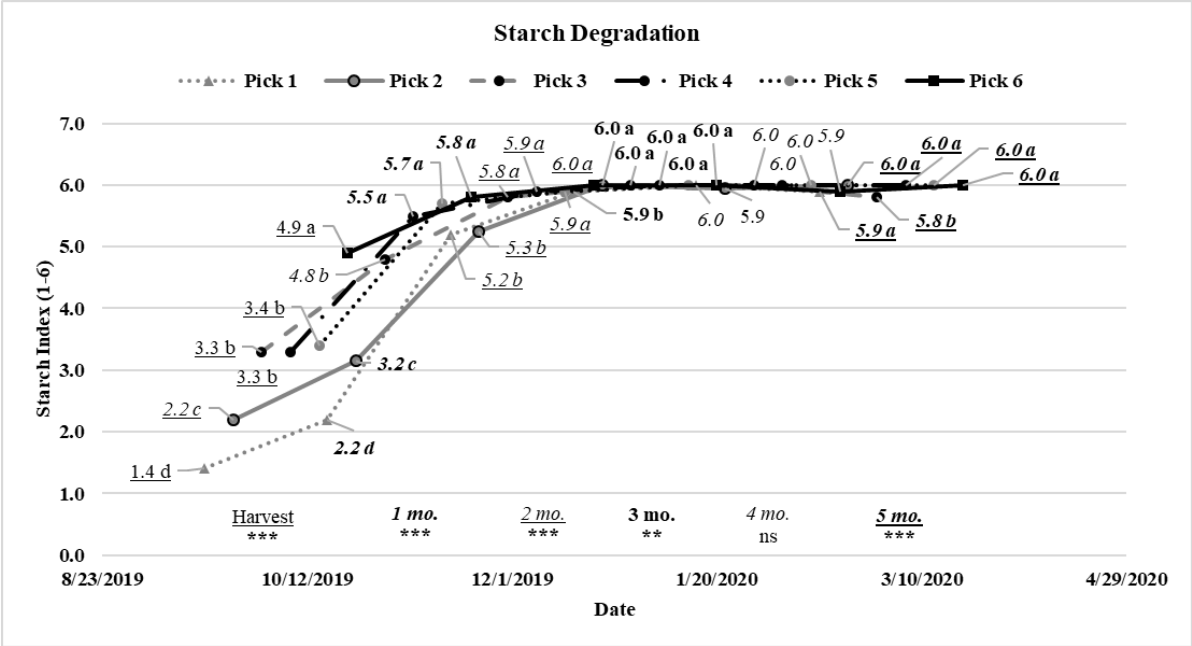

Figure 5: WA38 starch degradation by picking dates from September 17th to October 22nd.
*Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

Objective 3) Assess consumers' acceptance of WA38 fruit harvested at a different time (4 consecutive weekly picks).

Apple flavor was assessed from T0 to T2. Results revealed a higher incidence of starchy/unripe flavor in Pick1 apples, significantly higher than in all the other 5 picks. Starting from Pick2, 80% of the tasted apples showed a ripe/good flavor. Only at Pick6, there was a small percentage of apples tasting bland/no flavor (2.5%, data not shown). Flavor after 30 days (T1) showed that apples from Pick1 decreased the proportion of starchy/unripe apples from 92.5% to only 32.5%, while some bland/no flavor apples appeared in Pick4 and Pick5 (but not statistically different across the 6 picks) and from Pick4 to Pick6, at least the 88% of tasted apples were in the good/ripe flavor range (Figure 6).
After 1 day at room temperature, no significant differences emerged for flavor. However, the highest proportion of apples with good flavor were those in Pick3, while later picks revealed some bland/off-flavor (Figure 6). After 7 days at room temperature, the best-flavored apples belonged to Pick 1 to 4.
As judged by panels of untrained consumers consisting of over 200 unique participants in 2 days, picking date did not lead to many noticeable differences in perceived taste prior to many days of ripening except for consumer liking of apple flavor where Pick4 displayed significantly lower consumer liking relative to pick 5, with other picks falling in-between. However, after 7 days of room-temperature (RT) ripening, consumer liking of apple flavor was significantly higher in Picks 2, 3, and 6 relatives to the lowest liking of Pick1, resulting in the significantly better overall liking of Pick 2 and the least overall liking of pick 1. No significant differences in consumers' preference regarding firmness, crunchiness, juiciness, or sweetness were found among picks at either 1 or 7 days of room temperature ripening. These results would indicate that the effect of the pick date was not perceivable for individual liking attributes. However, as fruits ripened at room temperature, consumers could distinguish a better liking for later apple picks, with Pick1 standing out as the significantly least-liked apple for flavor and overall liking. In this sense, we can identify a threshold in consumer preference between Pick 1 and Pick 2 in terms of apple flavor and overall liking (Table 5).

Table 4: Flavor assessment on WA38 from P3 orchard Quincy by pick and comparison between T0 and T1 (at harvest vs after 30d of storage) in 2019.

*Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

pick	time	rep =trees (10apples/ tree)	Flavor 1 (unripe-sour/starchy) %	Flavor 2 (ripe/apple flavor) %	Flavor 3 (bland/no flavor) %
PICK1	T0	8 (5)	93 A	8 B	0
PICK1	T1-30d	8 (5)	33 B	68 A	0
Significance T0-T1			***	***	
PICK2	T0	8 (5)	20	80	0
PICK2	T1-30d	8 (5)	20	78	3
Significance T0-T1			**NS**	**NS**	**NS**
PICK3	T0	8 (5)	20 B	80 A	0
PICK3	T1-30d	8 (5)	58 A	43 B	0
Significance T0-T1			**	**	
PICK4	T0	8 (5)	38 A	63 B	0
PICK4	T1-30d	8 (5)	3 B	93 A	5
Significance T0-T1			**	*	**NS**
PICK5	T0	8 (5)	13	88	0
PICK5	T1-30d	8 (5)	5	88	8
Significance T0-T1			**NS**	**NS**	**NS**
PICK6	T0	8 (5)	10	88	3
PICK6	T1-30d	8 (5)	0	100	0
Significance T0-T1			**NS**	**NS**	**NS**

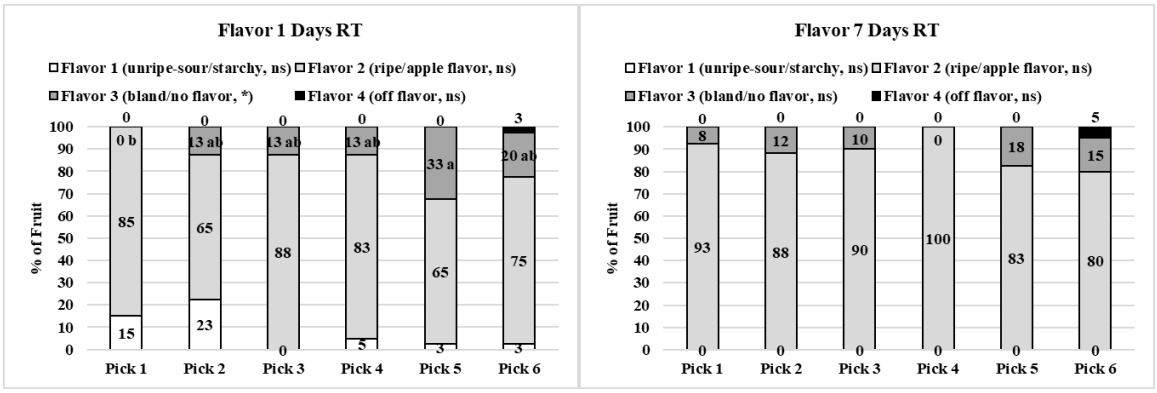

Figure 6: WA38 flavor assessment at the industry selling time (T2) plus 1 or 7 Days of room temperature (RT) ripening by picking sates from September 17th to October 22nd.

Table 5: WA38 consumer preference ratings at the industry selling time (T2) plus 1 or 7 Days of room temperature (RT) ripening by Picking Dates from September 17th to October 22nd (by Prof. Carolyn Ross). *Significance: *, p<0.05, **p<0.01, ***, p<0.001, NS= not significant difference.*

Pick	Evaluation	Firmness	Crunchiness	Juiciness	Sweetness	Apple Flavor	Overall Liking
Pick 1	1 Days RT	7.43	7.65	7.44	6.98	7.04 ab	7.03
Pick 2		7.62	7.61	7.63	7.02	7.05 ab	7.04
Pick 3		7.6	7.7	7.64	7.03	7.26 ab	7.26
Pick 4		7.48	7.63	7.55	6.88	6.95 b	7.13
Pick 5		7.74	7.79	7.64	7.03	7.38 a	7.35
Pick 6		7.65	7.69	7.68	7.17	7.29 ab	7.34
	Significance	ns	ns	ns	ns	*	ns

Pick	Evaluation	Firmness	Crunchiness	Juiciness	Sweetness	Apple Flavor	Overall Liking
Pick 1	7 Days RT	7.27	7.39	7.25	6.89	6.68 b	6.73 b
Pick 2		7.37	7.32	7.39	7.02	7.17 a	7.13 a
Pick 3		7.38	7.4	7.44	7.13	7.12 a	7.12 ab
Pick 4		7.5	7.46	7.51	7.01	7.07 ab	6.99 ab
Pick 5		7.42	7.41	7.4	7.03	6.99 ab	7.06 ab
Pick 6		7.39	7.32	7.44	7.02	7.15 a	7.10 ab
	Significance	ns	ns	ns	ns	*	*

PROJECT OUTCOMES

Presentations:
Musacchi S., 2020. WA38 Pre-harvest Q/A. Date Time: September 23rd, 2020.
Musacchi S., 2020. WA38 Live Field Day Webinar. Date Time: September 16th, 2020.
Musacchi S., Serra S., Ross C., Mendoza M., Schmidt T. 2020. Optimizing harvest time for WA38 Sub-quality committee meeting. March 24th, 2020.
Musacchi S., Serra S., Ross C., Mendoza M., Schmidt T. 2020. Optimizing harvest time for WA38. Continuing report 7M out of 12M Apple Review Yakima January 29th, 2020.

Publications:
WA 38 Defects Guide. WA 38 Common Defects and Unique Characteristics Near Harvest and During Storage. Written by Ines Hanrahan and Carolina Torres. Collaborators: Stefano Musacchi, Sara Serra, Kate Evans, Karen Lewis, David Rudell, Manoella Mendoza, Mackenzie Perrault, Jill Burberry.

FUTURE DIRECTIONS

Our preliminary research (one-year) highlights the harvest time's role in fruit quality and defects appearance and incidence—one trait of WA38 has been determined as a potential problem, the greasiness. More studies on greasiness, especially in post-harvest, can lead to the optimization of the WA38 storage.

EXECUTIVE SUMMARY

Project Title: Optimizing harvest time for WA38

Keywords: WA38, fruit quality, consumer preference, greasiness, starch

The project wants to investigate the effects of harvest time on fruit quality, starch degradation, and consumer acceptance of WA38 apples. WA38 internal quality of the fruit at harvest and during storage varies depending on the date of harvest. The most utilized method to determine harvest time in the apple is to estimate internal starch content by an iodine-staining index. Growers, packers, and researchers widely utilize the iodine test because it is a feasible and fast tool to adopt from the field to the lab. WTFRC has recently developed a specific WA38 starch scale (starch index 1-6) because the cultivar presents two patterns of starch degradation. The project wants to determine the starch degradation trends on different harvest days.

Within a WA38 P3 block in Quincy (trees planted in 2008 and grafted on M9337, 12 ft x 3 ft, 1210 trees/Acre, and 1360ft of elevation), in August 2019, we selected 48 trees for this trial. For each of the 6 harvests (picks), we randomly choose 8 trees available as reps. The first pick starts on September 17th, 2019, and the last ends on October 22nd, 2019.

The size of WA38 fruit improved significantly more delayed was the pick; indeed, Pick6 had 21.8% more fruit belonging to the size 64 apples/box (=85 mm) than Pick1 (with only 4.7%).

The color was always at the highest level (50 to 100% red colored surface) since Pick1 to Pick6, ranging from 94% to 100%. Green spot did not significantly affect this production, reaching a maximum of only 4.4% at Pick2, while all the other harvest dates were affected at a lower incidence.

The delay in harvesting is affecting the grading quality of fruit. Among all the possible reasons to cull the fruit, we observed that later was the harvest date higher was the incidence of defects like bird peck and split. The split was reason to cull apples for the 4% at Pick1, while 6 weeks later, the proportion got tenfold (40% culled for the split, mainly stem split).

After storage, the proportion of fruit considered clean and “grease-free” appeared on average to be greatest in early pick dates (Pick1 through 3, > 95% of fruit considered “clean”). Similarly, the average proportion of apples with some greasiness (“slight grease”) was higher in later picks (Pick 5 and 6). After 7 days of room temperature ripening, apples from all picks showed an increase of greasiness.

Non-destructive assessment of dry matter and soluble solids revealed no significant differences among pick dates at both 1 and 7 days of room temperature ripening at the industry selling time, confirming a previous project’s findings.

At industry selling times (December 2019), starch differences among pick dates were subtle but significant and reflected the patterns seen at-harvest. Comparing each pick date, we saw significant increases in starch index between 1 and 7 days of room-temperature ripening in Pick1-4, indicating further conversion of starch to sugars as the fruit ripens at room temperature. No further change in the starch index was detected in Pick5 and Pick6, suggesting no further evolution of these fruits were possible as measured via starch index. Starch levels in the first two months after harvest reflected differences at-harvest (i.e., Pick1 had lowest, Pick6 had highest). After two and a half months of storage, all apples had roughly the same starch, regardless of the picking date, indicating a homogenization of fruit during storage.

Flavor after 30 days (T1) showed that apples from Pick1 decreased the proportion of starchy/unripe apples from 92.5% (at harvest, T0) to only 32.5%, while some bland/no flavor apples appeared in Pick4 and Pick5 and from Pick 4 to Pick6, at least 88% of tasted apples were in the good/ripe flavor range.

As judged by panels of untrained consumers, consisting of over 200 unique participants in two days, picking date did not lead to many noticeable differences in perceived consumer preference. After 7 days at room temperature, Pick2 and Pick3 showed a numerically higher overall liking value than the other harvest dates.