Project Title: Improving Apple Fruit Quality and Postharvest Performance

Report Type: Final Project Report

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- Stemilt: Rob Blakey, Hannah Walters, Enrique Garcia
- WA 38 folder distribution: WSU Tree Fruit Extension Team, Agrofresh, GS Long, Storage Control Systems
- WA 38 industry discussion group: Chris Hedges (WSU, organizer after the first meeting), Carolina Torres (WSU), Matt Miles (Allan Bros.) AHP chair, Ines Hanrahan (WTFRC), Manoella Mendoza (WTFRC), Jenny Bolivar-Medina (WSU), Tyler Brandt (PVM), Chris Hargraves (Yakima Fruit), Garrett Grubbs (Chelan Fruit), Lauren Gonzalez (GS Long), Jordan Walker (Roche Fruit), Tom Butler (former member of apple maturity program, Washington Fruit), Craig Anderson (Gilbert Fruit), Jon Onstad (Sage Marketing), Mark Hanrahan (Knight Hill Orchards), others by invitation

Project Duration: 3 Year

Total Project Request for Year 1 Funding: $ 24,639
Total Project Request for Year 2 Funding: $ 25,327
Total Project Request for Year 3 Funding: $ 26,056

Other related/associated funding sources: in-kind contributions.
Most supplies and fruit are donated by industry cooperators (approx. value: $5,000). WA 38 information folder printing and assembly was covered by WSU Extension. All costs for re-printing of the WA 38 starch scale are covered by Storage Control Systems.

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Item	2020	2021	2022
Salaries			
Benefits			
Wages	$15,450.00	$15,900.00	$16,377.00
Benefits	$8,189.00	$8,427.00	$8,679.00
RCA Room Rental	$0.00	$0.00	$0.00
Shipping	$500.00	$500.00	$500.00
Supplies	$500.00	$500.00	$500.00
Travel			
Plot Fees			
Miscellaneous			
Total	$24,639.00	$25,327.00	$26,056.00

Footnotes: Wages and benefits calculated at a yearly increase rate of 3%

The internal program of the WTFRC provides support to scientists and industry. Staff frequently collaborates with a wide variety of programs. The high-priority industry needs not covered elsewhere are tackled by the WTFRC program.

Objectives

1. WA 38 Outreach Material
   a. Distribution of WA 38 starch scale (1-6)
   b. Development of a WA 38 apple defect guide (2020)
   c. Develop harvest criteria information for commercial WA 38 storage (2020 to 2022)
   d. Greasiness incidence summary (published in the Fruit Matters Newsletter 2021 and 2022)
2. WA 38 Collaborative Efforts
   a. Participation in WSU meetings and field days (2020 and 2021)
   b. Lead scientific input to PVM (Marketing & Quality Standard, 2020 to 2022)
   c. Assisting WSU researchers with WA 38 projects
   d. Coordination of WA 38 fruit sampling for Decco, Pace, and Crunch Pak (2020)
   e. WA 38 Industry discussion group
      i. Development of wax protocol (2021)
3. WA 38 Research Projects
   a. DPA phytotoxicity assessment (published in the Fruit Matters Newsletter 2022)
   b. Influence of 1-MCP treatment on fruit flavor considering the starch level at harvest (published in the Fruit Matters Newsletter 2022 and presented at the 2022 WSTFA Research News Flash)
   c. Influence of 1-MCP treatment on starch clearing during RA storage

Significant Findings

Objective 1: WA 38 Outreach Material

a. The WA 38 starch scale was finalized in 2019 and distributed at no cost to the industry. In 2020, 2021, and 2022 industry training was continued via extension events and the distribution of printed copies.
b. A variety-specific defect guide was developed for WA 38. It is available at the WSU Tre Fruit Extension website (http://treefruit.wsu.edu/wa-38-defects-guide).
c. The recommended harvest criteria for commercial WA 38 storage document was developed for the 2021 storage season and updated for 2022. It is available at the WSU Tree Fruit Extension website (http://treefruit.wsu.edu/) under WA 38 resources.
d. Greasiness incidence on WA 38 apples from pre-commercial plantings (ABP phase 3) was summarized. It is influenced by tree age, most prevalent in fruit from young trees (2-3 years old).

Objective 2: WA 38 Collaborative Efforts

a. The in-person meetings held by the WSU extension team had a wide range of participants, including growers, packers, retailers, and researchers (Engl./Span.).

b. The WA 38 Marketing and Quality Standards document was developed for the 2021 season and updated in 2022. It is available at the WSU Tree Fruit Extension webpage (http://treefruit.wsu.edu/) under WA 38 resources. WTFRC facilitated annual scientific input to PVM.
c. Assisted Bernardita Sallato, Karen Lewis, and Meijun Zhu with WA 38 harvest, quality analysis, storage, and transportation.
d. In 2020, several bins of WA 38 were supplied to Decco, Pace, and Crunch Pak to accelerate work on wax and greasiness issues
e. The industry discussion group, under the leadership of Dr. Hanrahan, developed a WA 38 generic waxing protocol is available at the WSU Tree Fruit Extension webpage (http://treefruit.wsu.edu/wa-38-resources/2022-generic-cosmic-crisp-waxing-protocol/)

Objective 3: WA 38 Research Projects

a. DPA phytotoxicity assessment
    i. Diphenylamine (DPA) at 2100 ppm did not cause phytotoxicity on WA 38 apples
b. Influence of 1-MCP treatment on fruit flavor considering the starch level at harvest
    i. The lowest incidence of good flavor in WA 38 was from apples harvested at starch 1.5 (45%) and stored in RA for up to six months. Under the same conditions, fruit harvested at starch levels from 2.0 to 4.5 had better flavor (83 to 100% of good flavor).
    ii. WA 38 apples had a higher percentage of good flavor when not treated with 1-MCP and stored in CA, except at ten months of storage.
    iii. For WA 38 stored in CA, the average fruit firmness was above 17.0 lb., regardless of treatment and storage length.
c. Influence of 1-MCP treatment on starch clearing during RA storage
    i. There was a higher variance between and within treatments in the first few weeks, but the variability decreases over time
    ii. In the first year of the study, the starch degradation in short-term RA storage develops similarly for fruit with and without 1-MCP treatment

Methods

Objective 3: WA 38 Research Projects

In 2021 the WA 38 discussion group met weekly from August to mid-November, via ZOOM and three times in person. During the discussion, the industry members expressed interest in the issues that were investigated in the following projects:

a. DPA phytotoxicity assessment

Diphenylamine (DPA) is an antioxidant compound used for postharvest control of superficial scald on apples. DPA application is very common on Granny Smith apples due to their high superficial scald susceptibility. DPA is also known to cause phytotoxicity on apples, making them unmarketable. The treatment is often applied by drenching with a mix of DPA and a postharvest fungicide but can also be applied via aerosol or fogging within the storage room.

Since no evidence of superficial scald has been seen on WA 38 apple, DPA application is not recommended, but a postharvest fungicide application is advised to decrease postharvest losses from decay. Because Granny Smith and WA 38 harvest timing overlap, a warehouse may face logistics challenges in applying a fungicide alone while avoiding DPA treatment on WA 38.

To assess DPA phytotoxicity on WA 38, apples were harvested from an orchard near Rock Island and another near Quincy in 2021. The apples were drenched with DPA at 2100 ppm mixed with the postharvest fungicide Academy (fludioxonil and difenoconazole). The apples were stored in refrigerated air (RA, 33°F) and evaluated every other week for four months. Phytotoxicity was assessed visually and recorded as absent or present. The sample size for Rock Island and Quincy were 165 and 183 apples, respectively. In 2022, two bins of WA 38 were drenched with a mix of DPA and the fungicide Penbotec (pyrimethanil), at a rate of 1900 ppm.

b. Influence of 1-MCP treatment on fruit flavor considering the starch level at harvest

The compound 1-methylcyclopropene (1-MCP) has been used as a postharvest storage treatment to slow fruit ripening. The 1-MCP binds to ethylene receptors and hinders ethylene-depended reactions, such as fruit maturation (Lee et al., 2012). It can improve firmness retention and reduce the incidence of storage disorders like superficial scald. However, 1-MCP efficacy is highly related to maturity at harvest and time of application, and in some instances, it may inhibit flavor development.

Data was collected from the WSU apple breeding program phase 3 (P3) orchards in Quincy and Prosser from 2010 to 2016. The trees were planted in 2008 on M9 337 rootstock in both locations. After harvest, a sample of 20 to 40 apples was collected and transported to the WTFRC laboratory in Wenatchee. At harvest, quality analysis, starch degradation and external evaluations were performed within 24 hours.

The storage samples, we harvested in 30lb. crates, drenched with a postharvest fungicide at one of the Stemilt facilities and stored in their research storage unit in Wenatchee. Half of each batch was treated with SmartFresh (1-MCP, 1000ppb) within one week of harvest, and samples were stored in refrigerated air (RA, 33°F) and controlled atmosphere (CA, 34°F, 1% CO2, 2% O2) to mimic standard commercial storage conditions. WA 38 was stored in RA for 2 to 6 months and in CA for 4 to 10 months.

Quality analysis of storage samples occurred at the WTFRC laboratory after seven days at room temperature(72°F) to closely mimic fruit quality as sampled by the consumer after transport and handling. Flavor assessment was conducted on 20 apples for each storage sampling combination during quality analysis. The flavor was classified as good, bland (no flavor), or off-flavor. We evaluated a total of 4,230 apples combining locations and years.

c. Influence of 1-MCP treatment on starch clearing during RA storage

Starch degradation is one of the most used procedures to determine apple harvest time. For WA 38 apples, the recommendation is that fruit should be harvested at a minimum starch of 2.0 (WA 38 starch scale: 1 to 6) (Hanrahan & Torres, 2022). For packing and shipping, 90% of the apples must reach or surpass 5.0. Previous studies have reported that fruit picked at 2.0 starch clearance will take an average of six weeks in refrigerated air (RA) storage to reach the required clearance (Musacchi et al., 2019). However, no data is available regarding the effect of 1-MCP treatment on the starch-clearing rate.

In 2021, WA 38 apples were harvested from an orchard near Rock Island, Washington, and immediately stored in RA (33°F). The apples were divided into three treatments: Control, MCP I, and MCP II. The fruit under MCP I and MCP II treatments were treated with SmartFresh^{TM} (100 ppb) 4 and 8 days after harvest, respectively. The apples in the control treatment were not treated with 1-MCP.

The starch degradation was evaluated visually using the WA 38 starch scale. The apples were removed from storage and sampled at room temperature by cutting through the equator and spraying the iodine solution. Starch was read 30 minutes after spraying. The data was collected every week for 11 consecutive weeks on 15 apples per treatment.

Results and Discussions

The WTFRC internal program has continued to focus part of its effort on fruit quality, postharvest, and extension. Due to the change in leadership at WTFRC in 2018, Manoella Mendoza assumed the role of staff lead for this internal program area. We plan to transfer the lead of this program to Dr. Torres (WSU, Endowed Chair Postharvest Systems) with the full support of the WTFRC internal Program.

WA 38 Outreach Material

a. Distribution of WA 38 starch scale (1-6)

A starch scale with detailed instructions was developed for WA 38 in 2019. It was distributed free of charge for the apple industry, and industry-wide training was performed in 2019, 2020, and 2021. It included workshops and field days coordinated by the Tree Fruit Extension Team. Over 1000 folders containing the starch scales and other relevant materials, such as the Marketing and Quality Standards and Recommended Harvest Criteria for commercial WA-38 Storage, were distributed at events.

The starch scales can be downloaded from the WSU Tree Fruit Extension website (http://treefruit.wsu.edu/wa38-starch-scale/). Printed materials can be requested from WTFRC, PVM, or WSU Tree Fruit Extension and will be provided to the industry at no cost.

b. Development of a WA 38 apple defect guide

A variety-specific defect guide was developed by Ines Hanrahan (WTFRC) and Carolina Torres (WSU) in 2020. The defect guide was developed with a focus on defects typically observed in WA 38 to date and includes three modules: defects visible during the growing season and at harvest, defects visible after storage, and unique characteristics of WA 38. It can be found at the WSU Tree Fruit Extension website (http://treefruit.wsu.edu/wa-38-defects-guide). The guide will be updated regularly**.**

c. Develop harvest criteria information for commercial WA 38 storage in 2020, 2021, and 2022

This effort was led by Ines Hanrahan and completed in collaboration with Carolina Torres. Input from the WSU extension team, PVM, and the WA 38 discussion group are included. The document is reviewed and updated yearly to include the latest research results. The 2022 recommendations are available at the WSU Tree Fruit Extension website (http://treefruit.wsu.edu/) under WA 38 resources.

d. WA 38 greasiness incidence in pre-commercialization plantings

The results of this research were published in the Fruit Matters Newsletter in September 2021 and August 2022. The goal was to assess the greasiness incidence of WA 38 apples from two pre-commercialization plantings (Apple Breeding program Phase 3) across years (2010- to 2016). Greasiness was assessed as absent or present at harvest and after refrigerated air (RA) and controlled atmosphere (CA) storage (up to 10 months). 1-MCP was applied in batches of fruit. A total of 4,960 apples from Quincy and 4,678 from Prosser were evaluated.

Greasiness is more prevalent in fruit from 2- to 3-year-old trees. Starch degradation level by tree age shows that WA 38 overall greasiness incidence is not related to starch levels at harvest (Figure 1). For example, Quincy starch levels at harvest were 1.6 for both 2- and 4-year-old trees, but the greasiness levels were 88.9% and 0.8 %, respectively. Similarly, 3- and 6-year-old trees from Prosser had a 2.2 starch degradation level at harvest, and a greasiness incidence of 53.0% and 12.7%, respectively.

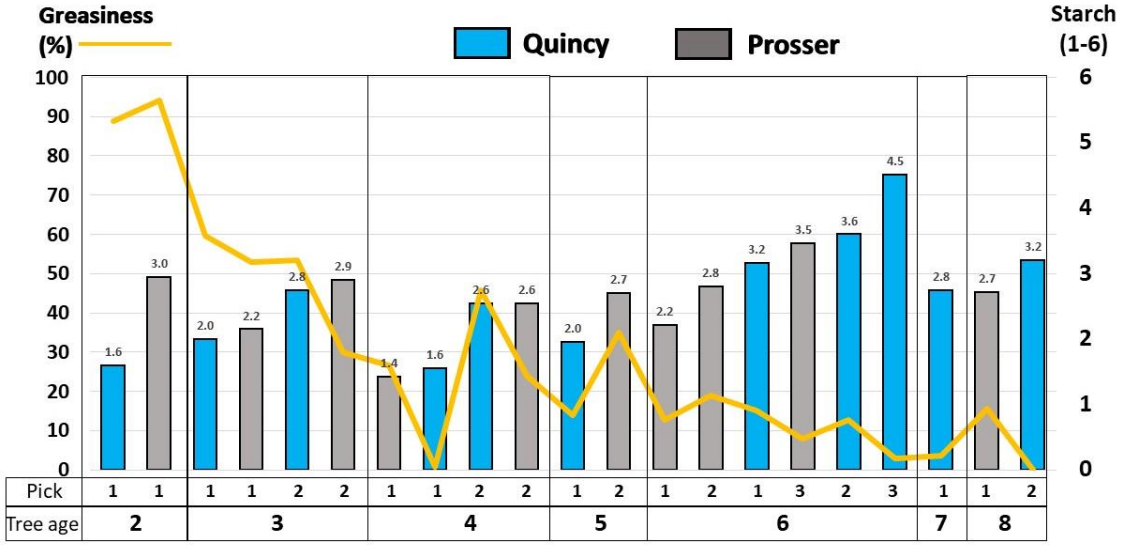

Figure 1. Effect of tree age and starch degradation level at harvest on WA 38 greasiness (%) incidence after storage

Fruit stored in (RA) typically develops more greasiness than fruit stored in CA (data not shown). Treatment with 1-MCP suppresses greasiness development during storage in mature orchards but is less effective during the first few years, when greasiness is high (data not shown). More information can be found at the WSU tree fruit and extension website. (http://treefruit.wsu.edu/article/wa-38-greasiness-incidence-in-pre-commercialization-plantings/)

WA 38 Collaborative Efforts

a. Participation in WSU meetings and field days

Field days in Spanish were conducted in 2021 and 2022 by Jenny Bolivar (member of the WSU extension team). The WTFRC assisted with printing material, folder organization, and distribution. Ines Hanrahan was a presenter at the Spanish field days, focusing on apple quality, the use of the starch scale, and postharvest issues. The WTFRC staff assisted with event logistics.

b. Led Scientific input to PVM

PVM has published the Marketing & Quality Standard, based on scientific input provided by a group of researchers under the leadership of Ines Hanrahan. It includes updated starch specifications for harvest and shipping, stem clipping recommendations, grading criteria for defects and color, and compliance actions. The document is reviewed and updated annually by the Quality Standards Advisory Committee. It can be found on the WSU Tree Fruit and Extension webpage (http://treefruit.wsu.edu/treefruit.wsu.edu%2Farticle%2F2022-commercial-harvest-and-storage-criteria%2F). For more information on industry guidance, refer to https://quality.cosmiccrisp.com/

c. Assisted WSU researchers with WA 38 projects

Helped Bernardita Sallato (WSU) and Karen Lewis (WSU) with the harvest of several bins of WA 38 in Prosser in 2021. WTFRC crew transported and stored the bins at Stemilt RCA in Wenatchee. WTFRC further assisted in conducting titratable acidity analysis for a WA 38 experiment. For Meijun Zhu, three bins of WA 38 were harvested from the Sunrise orchard, in 2020 and 2022. The apples were stored at Stemilt in Wenatchee and transported to Pullman to be used in food safety projects.

d. Coordination of WA 38 fruit sampling for Decco, Pace, and Crunch Pak

The WTFRC coordinated with Lee Kalcsits (WSU) and Bernardita Sallato (WSU) to make fruit samples (bins) available to allied industry partners to accelerate work on wax and greasiness issues.

e. WA 38 industry discussion group

A group of industry representatives met in 2021 in 2022 to discuss WA 38 industry issues. In 2021 the group met weekly from August to mid-November, via ZOOM and three times in person. Under the leadership of Dr. Hanrahan, the group developed a WA 38 generic waxing protocol, available on the WSU Tree Fruit Extension webpage (http://treefruit.wsu.edu/wa-38-resources/2022-generic-cosmic-crisp-waxing-protocol/).

Eight hybrid and two in-person meetings were held in 2022. Dr. Hanrahan continued leading this effort joined by Matt Miles (Apple Horticulture and Postharvest Committee Chair). The mailing list currently has 76 members, and everyone interested is welcome to join.

<u>WA 38 Research Projects</u>

a. DPA phytotoxicity assessment (published in the fruit matters newsletter 2022)

In 2021, WA 38 apples treated with a mix of DPA and Academy at 2100 ppm did not develop phytotoxicity symptoms during the four months of observation. This result indicates that WA 38 could be drenched with a fungicide solution containing DPA. We only tested two lots of fruit. Distinct lots may present different levels of sensitivity to a chemical burn. In 2022, 2 bins were drenched with DPA and Penbotec at 1900 ppm. Evaluations are ongoing. It is generally not recommended to use DPA on WA 38 because it does not develop superficial scald.

b. Influence of 1-MCP treatment on fruit flavor considering the starch level at harvest (published in the fruit matters newsletter 2022 and presented in the 2022 WSTFA Research News Flash)

The treatment combinations corresponding to each pick date were grouped based on starch reading at harvest and associated with the flavor classification received during fruit quality analysis after storage. The results below are based on the combined results of fruit harvested at Prosser and Quincy from 2010 to 2016. The RA and CA samples are analyzed separately.

Most fruit stored in RA for up to six months did not receive 1-MCP treatment; thus, it was not possible to determine if 1-MCP had affected fruit flavor in this condition. When differentiating fruit by starch index at harvest, more than 80% of the WA 38 apples were classified as having good flavor, except for fruit harvested at 1.5 starch, of which less than half had good flavor (Figure 3).

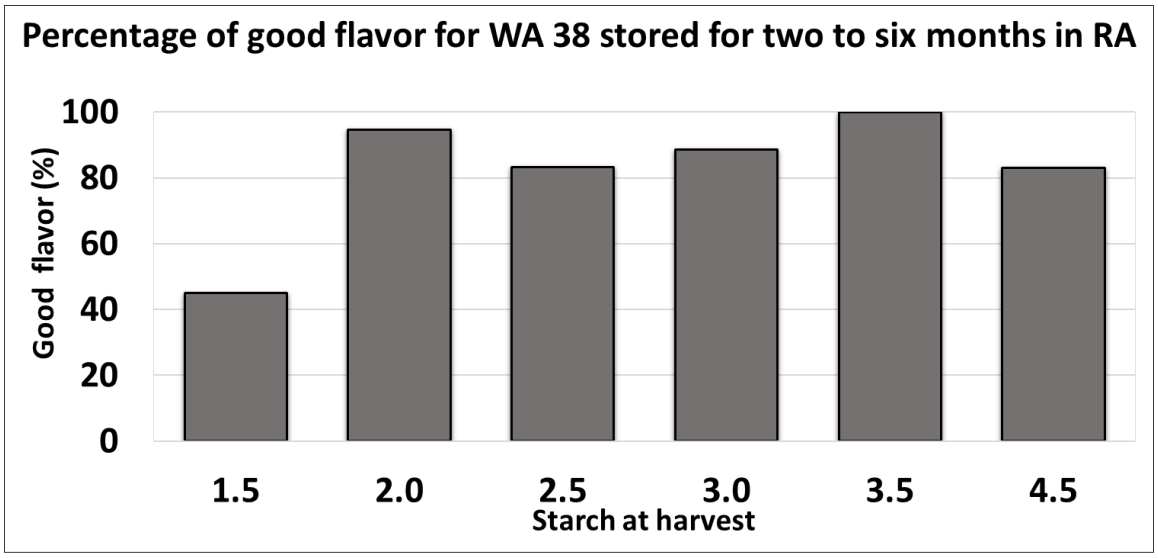

Figure 3. Percentage of good flavor by starch degradation level at harvest of apples stored for up to six months in RA. Total fruit evaluated equal 1040.

At six and eight months of CA storage, at least 90% of the apples harvested at 2.0 to 4.5 starch were classified as having good flavor regardless of 1-MCP treatment (Table 1). However, the fruit treated with 1-MCP scored lower than the untreated fruit at six months and equal to or lower at eight months of storage. Fruit harvested at 1.5 starch and stored in CA for six months had the lowest percentage of good flavor compared with fruit harvested in the 2.0 to 4.5 starch range. The apples treated with 1-MCP scored similarly to untreated fruit but achieved better flavor ratings at ten months in CA.

Table 1. Percentage of good flavor by starch degradation level at harvest for apples stored in CA for six, eight, and ten months with or without 1-MCP treatment. Data summary of fruit harvested at Prosser and Quincy from 2010 to 2016. Total fruit evaluated equal 3060.

	6 months CA		8 months CA		10 months CA	
	no 1-MCP	*1-MCP*	*no 1-MCP*	*1-MCP*	*no 1-MCP*	*1-MCP*
1.5	70	80			80	90
2.0	100		100	100	89	100
2.5	90				60	80
3.0	99	97	97	94	59	68
3.5	100	95	100	100		
4.5	100	97	100	100		
overall	**93**	**92**	**99**	**98**	**72**	**84**

Fruit firmness, titratable acidity and soluble solids were assessed at the same timepoints (data not shown). The average fruit firmness was above 17.0 lb., regardless of treatment and storage length. Apples treated with 1-MCP typically had higher firmness than untreated apples. However, the treatment difference was usually less than 1.0 lb., except for apples harvested at starch level 3.0 and stored in CA for ten months (diff. 1.7lb.). Titratable acidity and soluble solids concentration were comparable between 1-MCP treated and untreated fruit. Greasiness incidence was discussed in the WA 38 outreach material section.

Considering fruit flavor ratings, quality parameters, and greasiness incidence, applying 1-MCP might be beneficial only for the longest-term CA storage if apples are harvested at a 3.0 starch level. For six to eight months of storage, 1-MCP does not appear advantageous or cost-efficient as it may be detrimental to fruit flavor and has no effect on quality parameters.

c. Influence of 1-MCP treatment on starch clearing during RA storage

The starch degradation evolved similarly for the three treatments, increasing by about 1.5 units in 11 weeks. However, rather than a sequential stepwise increase, the starch averages oscillated ± 0.4 units overall between sampling dates (Figure 4). WA 38 apples are ready for packing and shipping when 90% of the apples reach or surpass 5.0 (WA 38 starch scale:1-6). According to the data collected, fruit from control and treated with 1-MCP at four (MCP I) and eight (MCP II) days after harvest would be ready for packing on December 17th,10th, and 23rd, respectively, which is a month later than the sale release date. It is important to mention that the data collected does not indicate the inadequacy of the chosen packing and shipping date, rather, it emphasizes the need for starch assessment for every fruit lot before packing.

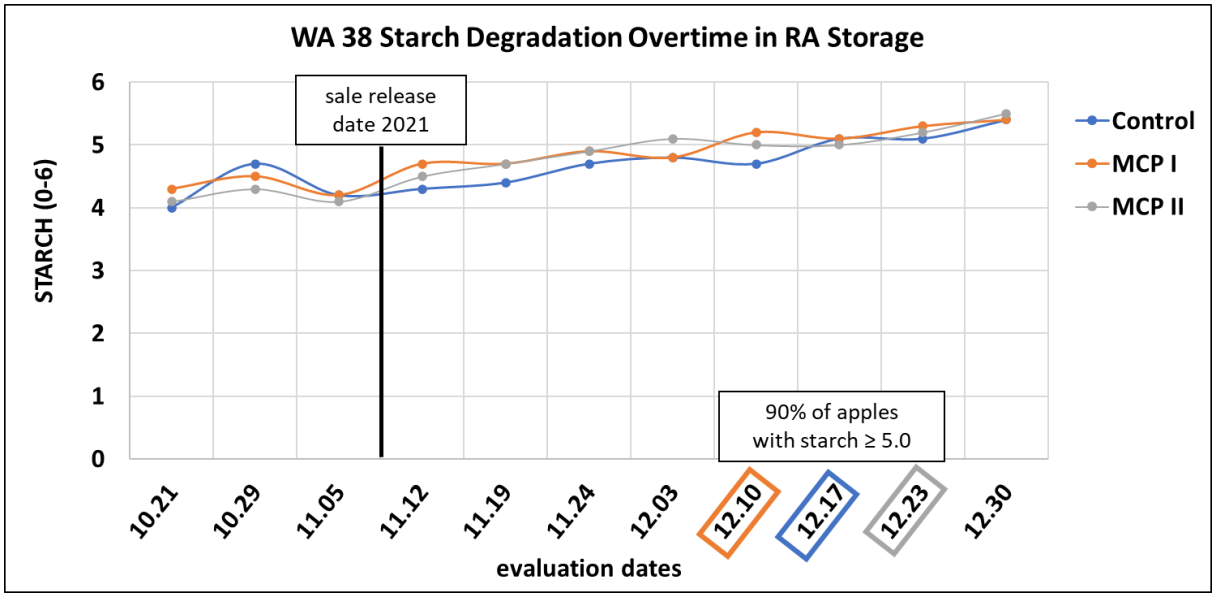

Figure 3. Weekly starch degradation of WA 38 apples stored in RA in 2021. Apples were treated with 1-MCP at four (MCP I) or eight days (MCP II) after harvest. The control treatment did not receive 1-MCP treatment. The date on which 90% of apples reach starch degradation equal to or above 5.0 is December 10th, 17th, and 23rd, for control, MCP I and MCP II, respectively.

There was a slightly higher sample variability on fruit treated with 1-MCP when compared with control. This variation was higher on MCP I, followed by MCP II. The starch deviation within treatment per sampling time decreased over time, showing that apple-to-apple variability declined as fruit matures in storage regardless of treatment (Table 2).

Table 2. Starch degradation variability (standard deviation) of WA 38 apples stored in RA per sampling time and treatment. A darker to lighter yellow shade is used to identify higher to lower variability.

	Standard deviation – variability within treatment										
treatment	10.21	10.29	11.05	11.12	11.19	11.24	12.03	12.10	12.17	12.23	12.30
Control	± 0.4	± 0.3	± 0.5	± 0.5	± 0.4	± 0.4	± 0.3	± 0.4	± 0.3	± 0.3	± 0.3
MCP I	± 0.6	± 0.4	± 0.6	± 0.6	± 0.3	± 0.6	± 0.3	± 0.4	± 0.3	± 0.3	± 0.3
MCP II	± 0.6	± 0.6	± 0.4	± 0.4	± 0.4	± 0.4	± 0.4	± 0.4	± 0.3	± 0.2	± 0.3

The results suggest a slower starch degradation rate than reported in previous studies. In 2022, tree age will be considered, and the same orchard from 2021 will be sampled to account for year-to-year variability. WA 38 apples will be harvested from one young (2nd or 3rd leaf) and one mature (4th leaf or older) orchard. Half of the fruit will be treated with 1-MCP and stored in either RA or CA.

Project Title: Improving Apple Fruit Quality and Postharvest Performance

Executive summary

Keywords: WA 38 defect guide, WA 38 greasiness, WA 38 starch scale, WA 38 wax protocol

Abstract: The internal program of the WTFRC provides support to scientists and industry. Staff frequently collaborates with a wide variety of programs. The high-priority industry needs not covered elsewhere are tackled by the WTFRC program. This report includes WA 38 outreach material, collaborative efforts, and research results from 2019 to 2021.

Project Outcomes and Significant Findings

Objective 1: WA 38 Outreach Material

a. The WA 38 starch scale was finalized in 2019 and distributed at no cost to the industry. In 2020, 2021, and 2022 industry training was continued via extension events and the distribution of printed copies.
b. A variety-specific defect guide was developed for WA 38 (http://treefruit.wsu.edu/wa-38-defects-guide).
c. The recommended harvest criteria for commercial WA 38 storage document was developed for the 2021 storage season and updated for 2022 (http://treefruit.wsu.edu/).
d. Greasiness incidence on WA 38 apples is influenced by tree age, being most prevalent in fruit from young trees (2-3 years old).

Objective 2: WA 38 Collaborative Efforts

a. The in-person meetings held by the WSU extension team had a wide range of participants, including growers, packers, retailers, and researchers (Engl./Span.).
b. The WA 38 Marketing and Quality Standards document was developed for the 2021 season and updated in 2022 (http://treefruit.wsu.edu/). WTFRC facilitated scientific input to PVM.
c. Assisted Bernardita Salatto, Karen Lewis, and Meijun Zhu with WA 38 harvest, quality analysis, storage, and transportation.
d. Several bins of WA 38 were supplied to Decco, Pace, and Crunch Pak to accelerate work on wax and greasiness issues.
e. The industry discussion group, under the leadership of Dr. Hanrahan, developed a WA 38 generic waxing protocol (http://treefruit.wsu.edu/wa-38-resources/2022-generic-cosmic-crisp-waxing-protocol/).

Objective 3: WA 38 Research Projects

a. DPA phytotoxicity assessment
    i. Diphenylamine (DPA) at 2100 ppm did not cause phytotoxicity on WA 38 apples
b. Influence of 1-MCP treatment on fruit flavor considering the starch level at harvest
    i. The lowest incidence of good flavor in WA 38 was from apples harvested at starch 1.5 (45%) and stored in RA for up to six months.
    ii. WA 38 apples had a higher percentage of good flavor when not treated with 1-MCP and stored in CA, except at ten months of storage
    iii. For WA 38 stored in CA, the average fruit firmness was above 17.0 lb., regardless of treatment and storage length
c. Influence of 1-MCP treatment on starch clearing during RA storage
    i. There was a higher variance between and within treatments in the first few weeks, but the variability decreases over time
    ii. In the first year of the study, the starch degradation in short-term RA storage develops similarly for fruit with and without 1-MCP treatment