UNIVERSITY OF MARYLAND
OFFICE OF RESEARCH ADMINISTRATION

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December 22, 2020

Patti Keller
State Horticultural Association of Pennsylvania
480 Mountain Road
Orrtanna, PA 17353
patti@acnursery.com

Reference: Proposal Title: "Characterizing the effect of different harvest maturities and storage temperatures on fruit quality, ripening patterns, and chilling injury development of commercially important apple cultivars grown in the Mid-Atlantic Region"
UMD Proposal Number: 57958
UMD P.I.: Dr. Macarena Patricia Farcuh
DUNS #: 79-093-4285
EIN: 52-6002033

Dear Ms. Keller,

Please find enclosed the above referenced proposal submitted on behalf of the University of Maryland and signed by an Authorized Representative. We have assigned a University Proposal Number which you may use to reference this proposal in any future communication with our office. The budget request is in the amount of $6,799.

We acknowledge that Dr. Farcuh is identified by name as the PI at the University of Maryland and that she intends to carry out all responsibilities identified in the attached proposal. Should this submission result in an award, the University of Maryland is prepared to enter into an agreement under mutually acceptable terms and conditions for a State Institution of Higher Education.

Please direct any technical questions regarding this proposal to Dr. Farcuh at 301-405-1323 or mfarcuh@umd.edu. Administrative questions should be directed to Maura Collinge at 301-405-9743 or mcolling@umd.edu.

We look forward to collaborating with you on this project.

Sincerely,

Takeia M. Bradley
Digitally signed by Takeia M. Bradley
Location: University of Maryland
Date: 2020.12.22 08:32:49 -05'00'

Takeia M. Bradley
Assistant Director

Characterizing the effect of different harvest maturities and storage temperatures on fruit quality, ripening patterns, and chilling injury development of commercially important apple cultivars grown in the Mid-Atlantic Region.

Personnel:
Macarena Farcuh, Assistant Professor
2116 Plant Sciences Building/ 4291 Field House Drive
University of Maryland, College Park/ College Park, MD 20742-4452
Phone: 301.405.1323; email: mfarcuh@umd.edu

Duration of Project:
One year (continuation from 2020 funded project).

Justification:
This is a continuation (and final year) of the project funded in 2020. A second year of data collection is necessary to validate the results obtained in the first year. This is particularly important due to the abnormal environmental conditions of 2020. An expansion of the project beyond one year was discussed at the oral review held in January, 2020, at the PSU FREC facility in Biglerville, PA. Thus, the suggestion to expand into the 2021 growing season had already been identified as a possibility by the review panel. For this second year, as it is a validation year, the project will be scaled down by half, thus collecting half the amount of fruit harvested from each cultivar, and the request for funding will be reduced correspondingly, particularly in reference to the amount of hourly labor necessary, in the budget.

For decades the availability of apple cultivars to most consumers was limited (for example, cultivars such as Red Delicious, Golden Delicious, Granny Smith, McIntosh), producing a decrease in market value due to saturation of the market. The development and marketing of new apple cultivars has therefore been essential for the long-term profitability of US apple growers.

Several newly developed apple cultivars have expanded the production season and have the capacity to be marketed at premium prices. These cultivars compete successfully on world markets, and many have been adopted by growers in the United States. Among these, popular early season cultivars include Premiere Honeycrisp, Gala, Honeycrisp, and Daybreak Fuji while popular late season cultivars include Fuji, Cripps Pink, Gold Rush and MAIA-1 (EverCrisp).

Honeycrisp in particular has become very popular among consumers in the fresh fruit market due to its crisp texture and distinct flavor profile. This makes Honeycrisp a high-value cultivar, resulting in premium prices for growers. The use of cold storage enhances their value by extending their market life and providing a longer window of market availability.

Nevertheless, Honeycrisp is a chilling sensitive cultivar and can develop physiological disorders when cooled immediately after commercial harvest. Soft scald and soggy breakdown are considered chilling injury (CI) symptoms of and are characterized by development of irregular, but sharply demarcated dark brown patches in the apple peel and flesh, respectively. CI manifests when the fruit is re-exposed to room temperature, so this problem is not perceived until the fruit reaches consumers.

There are several factors that can affect CI susceptibility. These include genotype/genetic background, maturity at harvest time, orchard/pre-harvest factors, seasonal variations, and postharvest storage conditions. Prior research conducted in Minnesota, Michigan, Ontario and Nova Scotia has shown that the use of a temperature conditioning period at a relatively warm storage temperature (10-20 °C) after commercial harvest for up to seven days followed by storage at 3 °C reduces the development of CI during cold storage in Honeycrisp fruits. However, at these higher storage temperatures Honeycrisp fruits may become susceptible to bitter pit (a physiological disorder correlated with fruit calcium content which causes dark depressions on the fruit surface associated with the collapse of the flesh below the peel). The development of these physiological disorders during storage can cause significant economic losses as they seriously impact fruit quality rendering the fruit unmarketable.

Many of the new developed cultivars recently adopted by growers feature Honeycrisp as a parent in their genetic background. For example, late season cultivars such as MAIA-1 (EverCrisp) are the result of a controlled cross between Fuji and Honeycrisp cultivars. Due to the high susceptibility of these commercial cultivars to the development of physiological disorders such as CI, it is of great economic importance to characterize the effect of different harvest maturities and different storage temperatures on fruit quality. Although prior research has been conducted in other apple growing regions of the world, it is of crucial importance to characterize these aspects under the specific conditions of the Mid-Atlantic region. For instance, fruit respiration and ethylene production rates, which have been associated with fruit quality and with the development of physiological disorders, are strongly affected by environmental conditions and fruit maturity at harvest; thus, these need to be assayed under the specific conditions found throughout the mid-Atlantic.

This study will provide very useful preliminary information that could be used to apply for larger research grants focused on understanding fruit physiology of different apple cultivars. This would enable Pennsylvania and Maryland growers to improve their harvesting and handling practices, improve fruit quality for the consumer, and reduce the development of physiological disorders in key commercial cultivars.

Dr. Daniel Weber has agreed to collaborate on this project by coordinating fruit harvest with a local orchard (expected to be Bear Mountain Orchard, the site of the first experiment), assisting with data collection and analysis, and reviewing publications for submitted, as needed. (See attached letter of support.)

2021 SHAP Topical Priority List Categories:

Horticulture

- Strategic Management of Apple Variety Maturity Progression
- Maintaining Fruit Quality

Postharvest Physiology

- Methods of Retaining Fruit Firmness and Quality
- Alternative Methods for Fruit Storage

Objectives:

1. Measure apple maturity indices and ethylene and respiration production rates in apples from different cultivars, at three different harvest maturities during ripening on-the-tree.
2. Characterize the interaction of different harvest maturities and storage temperatures on fruit quality, ripening patterns, and CI development throughout postharvest storage.

Procedures:

1. **Measure apple maturity indices and ethylene and respiration production rates in apples from different cultivars, at three different harvest maturities during ripening on-the-tree.**

Fruits from Gala, Honeycrisp, Fuji and EverCrisp cultivars will be harvested from Bear Mountain Orchards located in Aspers, Pennsylvania, at three different harvest maturities during ripening on the tree: (a) one/two weeks before anticipated commercial harvest, (b) at commercial harvest, and (c) one/two weeks after commercial harvest (Table 1). Close communication with the orchard owner will be maintained to monitor season progression to predict commercial harvest dates.

Immediately following harvest, apples will be evaluated at the Fruit Quality Laboratory, University of Maryland (UMD), for:

- Ethylene and respiration production rates
- Fruit size (fresh weight and diameter)
- Skin color:
    - Surface color (percent red color and by using a Minolta colorimeter)
    - Ground color (using a Delta A meter, a Minolta colorimeter)
- Flesh color (using a Minolta colorimeter)
- Fruit firmness (Texture analyzer)
- Soluble solids (benchtop refractometer)
- Titratable acidity (malic acid equivalents, using an automatic titrator)
- Starch Pattern index (iodine-potassium iodide solution)

Pictures of the different cultivars at the different harvest maturities will also be taken.

2. **Characterize the interaction of different harvest maturities and storage temperatures on fruit quality, ripening patterns, and CI development throughout postharvest storage.**

Fruits harvested from each cultivar (Gala, Honeycrisp, Fuji and EverCrisp) at each of these three maturity stages, will be preconditioned at 10 °C (50°F) for 7 days + 90% Relative Humidity (RH), and submitted to two different postharvest storage conditions: at 0.5°C (33°F) + 90% RH and at 3.3°C (38°F) + 90% RH (Table 1). Storage is available at the University of Maryland for this project.

Fruits will be evaluated at two different periods during each storage treatment:

- After 2 months of postharvest storage + 7 days at 20°C (68°F) (Table 1)
- After 4 months of postharvest storage + 7 days at 20°C (68°F) (Table 1)

On the day of evaluation, apples will be evaluated at the Fruit Quality Laboratory for:

- Each of the characteristics listed above in Procedure 1.
- Physiological disorders development (disorder percentages will be calculated based on the percent of fruit that exhibited each certain disorder):
    - CI development: percentage of observed soggy breakdown and soft scald
    - Percentage of observed bitter pit

Pictures of the different cultivars at the different harvest maturities will also be taken.

Table 1. Breakdown of treatments by maturity stages at harvest (Objective 1) and postharvest storage conditions (Objective 2) for each cultivar assayed in this study based on the information above. A total of 22 pieces of fruit will be harvested for each treatment (4 biological replications × 5 pieces / replication = 20 pieces, plus an additional 10% to account for loss/attrition in shipping or processing).

Postharvest storage conditions	Evaluation periods for Objective 1 and Objective 2	Fruit Collected
(a) Fruit harvested one/two weeks before anticipated commercial harvest		
None	Harvest	22
0.5°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
3.3°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
(b) Fruit harvested at commercial harvest		
None	Harvest	22
0.5°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
3.3°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
(c) Fruit harvested one/two weeks after commercial harvest		
None	Harvest	22
0.5°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
3.3°C and 90% RH	2 months of storage + 7 days at 20°C	22
	4 months of storage + 7 days at 20°C	22
	Total number of fruits to harvest per cultivar:	**330**

Budget:

Hourly labor calculations for Objectives 1 and 2 are based off of the observed time required to complete the activities during the 2020 collection process. For Objective 1, there will be 24 distinct evaluations (4 cultivars × 3 maturity stages × 2 evaluations per harvest). For Objective 2, there

will be 48 distinct evaluations (4 cultivars × 3 maturity stages by 4 evaluation periods per stage). (Refer to Table 1 above for additional information.)

Budget Items	**Justification**	**Total May 2020-April 2021**
Hourly Labor 1	$12/hour × 6 hours/eval × 24 evals	$ 1,728.00
Hourly Labor 2	$12/hour × 6 hours/eval × 48 evals	$ 3,456.00
Fringe Benefits	Hourly labor at University of Maryland at 5.4%	$ 280.00
Travel	9 round trips to PA × 200 miles/trip × 0.575/mile	$ 1,035.00
Supplies	Farcuh lab and field supplies	$ 300.00
Total Direct Cost		$ 6,799.00
Capital Equipment		$ 0.00
Overhead		$ 0.00
Total Indirect Cost		$ 0.00
Total Request		**$ 6,799.00**

Other Support:
This proposal has not been submitted to another agency.

Results:
Research results will be published in the Pennsylvania Fruit News, and a poster will be presented at the Mid-Atlantic Fruit and Vegetable Convention as well as in Pennsylvania and Maryland growers' meetings.

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daniel.weber@psu.edu

The State Horticultural Association of Pennsylvania
480 Mountain Road
Orrtanna, PA 17353-8701

To the SHAP Research Committee:

I am writing this letter in support of the research proposed by **Dr. Macarena Farcuh**, Assistant Professor at the University of Maryland, titled "**Characterizing the effect of different harvest maturities and storage temperatures on fruit quality, ripening patterns, and chilling injury development of commercially important apple cultivars grown in the Mid-Atlantic Region**".

Dr. Farcuh has asked that I participate as a collaborator on this research by providing her with the following support:

- Contact potential grower collaborators and obtain commitments and authorization to conduct research trials in their commercial orchards.
- Locate and mark experimental replicates within blocks of the desired cultivars at each of these orchards.
- Collect, label, and deliver fruit samples harvested from these replicates at the intervals identified by the research protocols and based on grower collaborator feedback regarding harvest windows.
- Communicate with the grower collaborators once the research has concluded and ensure that all research materials are removed from the orchards prior to the end of the season.
- Review written evaluations of the research results prior to publication and assist with publication of the results in *Pennsylvania Fruit News* and via the Penn State Extension web site and *Fruit Times* newsletters.
- Assist with any other essential task within my power to ensure the success of this research.

I agree to these requests and am willing to support her in this research effort that undoubtedly will provide useful information to growers and managers of climate-controlled storage facilities throughout the Mid-Atlantic region.

Sincerely,

Daniel E. Weber, Ph.D.
Penn State Extension Educator, Adams County