

**FINAL PROJECT REPORT**

**YEAR:** 2 of 2

**PROJECT TITLE:** Complying with the FMSA Preventive Controls for Human Food Rule

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**COOPERATORS:** Claudia Coles (WSDA), Ines Hanrahan (WTFRC) and Various Packing Houses (Stemilt Growers, Double Diamond Fruit, Borton Fruit, Crane and Crane, Allan Brothers, Kershaw, Washington Fruits, Cowiche, Blue Bird, McDougall & Sons Inc, Columbia Reach)

**Budget:**            **Year 1:** \$48,711            **Year 2:** \$50,260

**Other funding sources:** The PI has some funds from the WSDA-SCBG program to support the one training on the PSFA-PCHF one day training. The event coordinator’s (Cathy Blood) time will be covered through the WSDA grant.

**Budget 1**

**Organization Name:** WSU  
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**Contract Administrator:** Katy Roberts  
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<b>Item</b>	<b>2017</b>	<b>2018</b>
<b>Salaries</b>	28,418	29,555
<b>Benefits</b>	2,580	2,683
<b>Wages</b>	7,261	7,552
<b>Benefits</b>	452	470
<b>Training Materials</b>	5,000	5,000
<b>Supplies</b>	2,000	2,000
<b>Travel</b>	3,000	3,000
<b>Miscellaneous</b>	\$0	\$0
<b>Plot Fees</b>	\$0	\$0
<b>Total</b>	48,711	50,260

**Footnotes:**

The majority of the funding requested is to cover graduate student wages. Funds are also requested for wages to support an undergraduate student to help with the project. Funds are requested to cover travel costs related to the project work, such as trips to the packing facilities in Wenatchee and Yakima for the work related to the first objective and for the trainings. Funds are also requested to cover supplies and training material costs that will be provided to the training attendees.

## ORIGINAL OBJECTIVES

In this project, we proposed to conduct a thorough assessment of a range of apple packing lines and identify the common practices that can be improved. These assessments were further to be utilized to develop a model food safety plan for the apple packing process.

The specific objectives of the proposal are as detailed below:

- 1) Develop a thorough assessment of the current apple packing process and packing house environments.
- 2) Develop model food safety plans for apple packing processes to help comply with the FSMA-PCHF rule.
- 3) Summarize the peer-reviewed literature available on the different technology interventions that are currently used in different produce industries.
- 4) Offer one, 2.5-day training on the FSMA-PCHF rule with an emphasis on the apple packing process, and two additional, 1-day trainings, focused on the implementation of the FSMA-PCHF rule.

## SIGNIFICANT FINDINGS

### Assessment of current packing facility practices:

Most apple packing houses fall under the FSMA Produce Safety Rule; however, the customers often expect them to comply with Preventive Control for Human Food Rule, which requires the development and implementation of the food safety plan.

- The cleaning and sanitation of the packing line are of crucial importance. However, it is often difficult because of the insufficient amount of time and problems with the rotation of employees.
- The biggest challenges identified by food safety managers were;
  - Design of facility and equipment.
  - Limited time for cleaning and sanitizing due to the high production rate.
  - The availability of water and the amount of water that would be used to conduct a proper sanitation of the flume piping and pump systems.
  - Restricted capacities of wastewater allowed for the municipal sewage system.
  - Budget limitation.
  - Personnel unawareness and high turnover.

### Food safety model plan development:

#### **Model food safety plan for the apple packing house was developed.**

- The observations of the current practices from the first objective were incorporated into this plan.
- A model food safety plan was shared, explained, and discussed with attendees of 1-day special FSMA-PCHF class (November 2<sup>nd</sup> 2018, and May 6<sup>th</sup> 2019).

### Summary of literature on different interventions:

- *L. monocytogenes* is a persistent, highly pathogenic microorganism that can pose a high risk in fresh produce operations. Abundant amounts of water used during the apple packing process, presence of wet surfaces, and difficult to clean equipment provide ideal conditions for *Listeria* growth and numerous paths for produce contamination.
- Removal of bacteria from the surface of the apple is difficult due to its morphology. The irregular shape of apples and the presence of microstructures on the apple peel surface

facilitate bacterial attachment. Bacteria harbored in the microstructures may be protected from cleaning interventions.

- Attacking bacteria by several different mechanisms through hurdle technology may help to improve the apple decontamination efficiency.
- Significant research is still needed for the development of effective strategies for reducing microbial loads on fresh apples. Critical aspects that should be considered include morphological characteristics of apples, conditions, and scale of the packing process, and influence of the interventions on apple quality.

## RESULTS & DISCUSSION

### Objective #1: Develop a thorough assessment of the current apple packing process and packing house environments.

The food safety practices vary significantly across the industry. Apple packing houses across the WA State are very motivated to improve food safety in their facilities. Substantial investment in food safety system was observed in recent years, and it continues to be one of the priorities in the management and development of apple packing facilities.

The cleaning and sanitation of the packing line are of crucial importance. However, it is often difficult because of the difficulty of cleaning equipment, an insufficient amount of time allowed for cleaning and sanitation, and problems with rotation of employees. Other challenges reported by food safety managers are a limited amount of water used to conduct proper sanitation of the flume piping and pump systems. Recycled systems are not designed to perform adequate sanitation. Restricted capacities of wastewater allowed for the municipal sewage system.

Currently used and potential solutions for improving food safety during apple packing process, based on the assessment of the current apple packing process and literature review are summarized in Table 1.

**Table 1. Currently used and potential solutions for improving food safety during apple packing process.**

Potential solution for reducing microbial load	
<b>Post-harvest fungicide treatment (drenching/fogging)</b>	<ul style="list-style-type: none"> <li>• Use of fogging method rather than drenching to avoid reuse of fungicide solution and minimize the possibility of cross-contamination of apples. Alternatively, the use of a fungicide solution does not support pathogen growth (Gomba et al., 2017; Guan et al., 2001; Ng, Fleet, and Heard, 2005).</li> </ul>
<b>Dump tank and flumes water treatments</b>	<ul style="list-style-type: none"> <li>• Use of double dump tank. The role of the first tank is to remove most of the debris and organic matter from the surface of the bins. It will greatly decrease the amount of organic matter, which causes a significant decline in sanitizer concentration. Thus, the concentration of sanitizer in the second tank and flumes will be more stable and easier to control (Luo et al., 2011).</li> <li>• Aeration in dump tank to help with total apple saturation while in the</li> </ul>

	<p>dump tank</p> <ul style="list-style-type: none"> <li>● Separation of dump tank from flumes.</li> <li>● Maintaining the quality of the water by use of sanitizing agents such as: chlorine, PAA, or EOW combined with surfactant.</li> <li>● Proper monitoring system (Suslow, 2004).</li> </ul>
<b>Brush bed: Fruit may be treated with soaps and/or sanitizers</b>	<ul style="list-style-type: none"> <li>● Application of surfactant combined with sanitizing solution. Brushing and rotating apples can help evenly cover apples with cleaning solution, increase detachment of microorganisms. Use of sanitizer ensure bacteria deactivation and prevent contamination of brushes and cross-contamination of subsequently washed apples.</li> <li>● Steam cleaning of wax brushes.</li> </ul>
<b>Wax coating: Fruit coated with food grade wax</b>	<ul style="list-style-type: none"> <li>● Application of wax with antimicrobial treatment (Jo et al. 2014)</li> </ul>
<b>Drying</b>	<ul style="list-style-type: none"> <li>● Automated dryer cleaning system to allow for more frequent dryer cleaning.</li> </ul>
<b>Personnel</b>	<ul style="list-style-type: none"> <li>● Frequent personnel training on understanding basics of food safety and personal hygiene.</li> </ul>
<b>Cleaning and sanitation</b>	<ul style="list-style-type: none"> <li>● Allowing enough time for sanitation crew to perform adequate cleaning, especially in Zone 1 and 2.</li> <li>● Reward system for sanitation crew, recognition of importance of their work.</li> </ul>
<b>Packing plant environment</b>	<ul style="list-style-type: none"> <li>● Automatic door foamers.</li> <li>● Forklifts designed only to the specific areas (i.e., forklifts used in cold room do not enter the packing area, forklifts in wet area are not used in the dry area).</li> <li>● Drain system accessible for cleaning</li> </ul>
<b>Other</b>	<p>Traceability system - geolocation system, room identification, specific lot and grower tagging.</p> <p>Efficient environmental monitoring program - seek and destroy approach.</p> <p>Support from chemicals and sanitation systems suppliers (often they provide trainings, ensure calibration and maintenance of the equipment, and provide information about new food safety interventions)</p>

**Objective #2: Develop a model food safety plan for apple packing processes to help comply with the FSMA Preventive Controls for Human Food Rule.**

Most of apple packing houses fall under the FSMA **Product Safety Rule**, which does not require the implementation of a food safety plan; however, the customers often expect them to comply with **Preventive Control for Human Food Rule**, which in turn requires a food safety plan. Required or not, a food safety plan can help facilities in managing the food safety system and ensuring the safety of the final product.

In this objective, we aimed to develop a model food safety plan that can be used by industry as an example, guide in developing their proper food safety plans. The food safety plan is based on hazard analysis for each step of the apple packing process. It is crucial to recognize all potential risks that can lead to contamination of the final product and identify the appropriate preventive controls for managing these hazards. In the case of the apple packing process majority of the hazards can be addressed by good manufacturing practices (GMPs) and sanitation preventive controls.

The drafted model food safety plan was reviewed by industry and by regulators (FSPCA), and based on obtained comments, the final version of the model food safety plan was developed.

**Objective #3: Summarize the peer-reviewed literature available on the different technology interventions that are currently used in different produce industries.**

Current FSMA-PCHF regulations require interventions in food safety to be based on scientific data. It is essential for the apple packing industry to find appropriate peer-reviewed literature to support the use of these technologies. This review provides the fresh apple packing industry with peer-reviewed literature on the effectiveness of these technologies. Based on the presented information, apple packers can make decisions on the use of different interventions. It can also aid in developing food safety plans.

The review includes supplementary information such as the possible routes of produce contamination, bacteria attachment, bacteria resistance mechanisms, and the mode of action of the common decontamination agents. This information can help to better understand the food safety risks, how cleaning treatments work, and why bacteria removal is so important.

Current methods of produce decontamination can be divided into chemical, physical, and biological methods that can be used individually or in combination. Scientific investigations on the efficacy of various decontamination methods have been conducted by numerous research groups. However, there is still a need for studies that will evaluate the suitability of a given method for application in the packing process of apples or other types of produce.

Lack of standard methodology for evaluating the efficacy of antimicrobial agents on fresh produce, laboratory-scale experiments, as well as differences between fresh produce morphologies makes it difficult to compare the results between studies and hard to predict their effectiveness in the industrial settings. A standardized methodology for the validation of the antimicrobial potential of sanitizing agents would facilitate a more objective and standardized evaluation.

Manuscript titled, "*Food Safety Interventions to Control Listeria Monocytogenes in Fresh Apple Packing Industry: A Review*" has been accepted for publication in the Comprehensive Reviews in Food Science and Food Safety Journal (Pietrysiak et al., 2019).

**Objective #4: Offer one, 2.5-day training, on the FSMA-PCHF rule with an emphasis on the apple and pear packing process, and two additional, 1-day trainings, focused on the implementation of the FSMA-PCHF rule.**

We offered 2.5-day training as a part of the WSDA-SCBG in 2017 and two 1-day trainings on implementation of the FSMA-PCHF rule with an emphasis on the apple packing process (November 2<sup>nd</sup> in Yakima and May 17<sup>th</sup> in Wenatchee). The 1-day training has been designed specifically for the attendees who have gone through the FSPCA standard Preventive Controls for Human Food (PCHF) Course. During the training, we shared with participants the food safety plan model, draft of literature review, and presentation slides. The training was well received, with full attendance and great feedback from attendees. During the training, we were able to assist some of the packers with their food safety plans and answer questions related to a different aspect of food safety.

## **REFERENCES:**

Gomba, A., Chidamba, L., and Korsten, L. (2017). Viable microbial loads on citrus carpoplane during packhouse processing and survival of foodborne pathogens in reconstituted postharvest fungicides. *Journal of Food Safety*.

Guan, T. Y., Blank, G., Ismond, A., and Van Acker, R. (2001). Fate of foodborne bacterial pathogens in pesticide products. *Journal of the Science of Food and Agriculture*. 81: 503-512.

Jo, W.-S., Song, H.-Y., Song, N.-B., Lee, J.-H., Min, S. C., and Song, K. B. (2014). Quality and microbial safety of 'Fuji' apples coated with carnauba-shellac wax containing lemongrass oil. *LWT-Food Science and Technology*. 55: 490-497.

Luo, Y., Nou, X., Yang, Y., Alegre, I., Turner, E., Feng, H., Abadias, M., and Conway, W. (2011). Determination of free chlorine concentrations needed to prevent *Escherichia coli* O157:H7 cross-contamination during fresh-cut produce wash. *Journal of Food Protection*. 74: 352-358.

Pietrysiak, E., Smith, S., & Ganjyal, G. M. (2019). Food safety interventions to control *Listeria monocytogenes* in the fresh apple packing industry: a review. *Comprehensive Reviews in Food Science and Food Safety*, 18(6), 1705-1726.

Ng, P. J., Fleet, G. H., and Heard, G. M. (2005). Pesticides as a source of microbial contamination of salad vegetables. *International Journal of Food Microbiology*. 101: 237-250.

Suslow, T. V. (2004). Oxidation-reduction potential (ORP) for water disinfection monitoring, control, and documentation. University of California. Division of Agriculture and Natural Resources (2004) Publication 8149.

## EXECUTIVE SUMMARY

Complying with the FMSA Preventive Controls for Human Food Rule

Keywords: Food Safety, FSMA, Food Safety Plan, Food Safety Training

The overall goal of this project was to increase the effectiveness of the food safety systems and help apple packing houses in complying with new FSMA-PCHF regulations. Based on (i) visits to various facilities; (ii) survey outcomes; (iii) scientific literature review; (iv) comments from industry and FSPCA, the **food safety plan model** was finalized.

The biggest challenges identified by food safety specialists are difficult (or impossible) to clean equipment, very limited time for cleaning and sanitizing, use and treatment of water, budget limitation, and personnel unawareness, and high turnover due to high production rate. Currently used and potential solutions for improving food safety during the apple packing process, based on the assessment of the current apple packing process and literature review were summarized.

Current methods of produce decontamination were reviewed and presented in a manuscript titled, "*Food Safety Interventions to Control Listeria Monocytogenes in Fresh Apple Packing Industry: A Review*" (is available online @ <https://doi.org/10.1111/1541-4337.12496>). Additionally, this review contains supplementary information such as the possible routes of produce contamination, bacteria attachment, bacteria resistance mechanisms, and the mode of action of the common decontamination agents. This information can help to better understand the food safety risks, how cleaning treatments work, and why bacteria removal is so important.

Scientific investigations on the efficacy of various decontamination methods have been conducted by numerous research groups. However, there is still a need for studies that will evaluate the suitability of a given method for application in the packing process of apples or other types of produce.

### Project outcomes:

- Developed a model food safety plan.
- Provided one, 2.5-day training on the FSMA-PCHF rule with an emphasis on apple and pear packing process (2017), and two additional, 1-day trainings, focused on the implementation of the FSMA-PCHF rule (2018, and 2019)
- Summary of the peer-reviewed literature available on the different technology interventions that are currently used in different produce industries presented in a published manuscript titled, "*Food Safety Interventions to Control Listeria Monocytogenes in Fresh Apple Packing Industry: A Review*" (<https://doi.org/10.1111/1541-4337.12496>)