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2900 100th Street, Suite 309, Des Moines, IA 50322-3855, USA

Ruofen Liao,[1] Gwenaël Engelskirchen,[2] Alicia Baddorf,[2] Isabella Tosta,[1] Thais Ramos,[2] and Erin DiCaprio[1]*

[1]Department of Food Science and Technology, University of California-Davis, Davis, CA 95616, USA

[2]University of California Sustainable Agriculture Research and Education Program, University of California Agriculture and Natural Resources, Davis, CA 95616, USA



An Interactive Workshop on Food Safety Best Practices for a Niche Fruit, the Western Blue Elderberry, Led to Increased Knowledge on Key Food Safety Concepts

ABSTRACT

The Western blue elderberry is a plant native to western North America. Alongside longstanding use by indigenous peoples in this region, its value in sustainable agricultural practices and potential to produce value added products has been increasingly recognized. As the market expands for the Western blue elderberry, food safety education is needed for those growing and processing this crop. In this work, a food safety educational program was developed specifically for this niche audience which included guidance documents, videos and in-person workshops. Topics for inclusion were informed by a needs-assessment survey on current practices utilized by those engaging in harvesting and processing of elderberries (n=45). The majority of respondents processing elderberries also grew and harvested the crop. The most common types of processing were drying, freezing, and manufacturing of syrups, cordials, jams, and teas. The workshops covered food safety best practices during harvesting, post-harvest handling, and processing of the Western blue elderberry. A retrospective pre-/post-learning assessment showed increases in knowledge in 32 individuals participating in two workshops. This work also provides insights related to two food safety risks associated with elderberries, cyanogenic glycosides and acidity, and highlights additional needs for research to evaluate risks associated with elderberries.

INTRODUCTION

Elderberry is an increasingly popular crop included in a variety of different consumer products. Both the fruit and flowers of the elderberry plant are used as ingredients in foods, nutritional supplements, personal care products, and in traditional medicines *(9, 14, 23, 24)*. The European black elderberry has been the most extensively studied for its concentrations of various anthocyanins, flavonoids, and polyphenolics *(14, 16, 17)*. Recent work has also determined the levels of these compounds, valued for antioxidant and other health promoting benefits, in the American and Western blue elderberry *(34)*. Beyond inclusion as a food ingredient, the anthocyanin diversity and concentration in various species and sub-species of elderberries has been investigated for its potential as a natural colorant *(13, 16)*.

*Author for correspondence: Phone: +1 530.753.6594; Email: eldicaprio@ucdavis.edu

There is geographic and regional diversity in elderberry. All elderberry plants are classified in the genus *Sambucus* L., which belongs to the Adoxaceae family *(22)*. While this genus contains numerous species and subspecies, the most commonly occurring species is *Sambucus nigra* L. *(42)*. This species has three subspecies, *S. nigra* L. ssp. *nigra* which is found in Europe and North Africa, *S. nigra* L. ssp. *canadensis* which is found in North America, and *S. nigra* L. spp. *cerulea* which is native to the western region of North America *(22, 42, 43, 44)*. While closely related, these three sub-species are unique. *S. nigra* L. ssp. *nigra* is commonly referred to as the European black elderberry or European elderberry. *S. nigra* L. ssp. *canadensis* is commonly called the American elderberry and has a very dark blue to black color. *S. nigra* L. ssp. *cerulea* is referred to as the Western blue elderberry and has a distinctive light blue color prior to ripening to a dark blue color. In California, cymes (clusters) of Western blue elderberries ripen at different times on a single plant during a window from late-July to early September.

Indigenous peoples were the first to utilize the Western blue elderberry for a variety of purposes *(20)*. This included utilization of various portions of the plant for tools as well as the use of elderflowers and elderberries for food and medicinal purposes *(20)*. While native Californians continue the traditional practices of cultivation, collection, and utilization of the Western blue elderberry, there is increasing interest in incorporating elderberry in farm hedgerows, a sustainable agriculture practice to enhance biodiversity and reduce soil erosion. The use of blue elderberry in hedgerows has the added benefit of producing fruits and flowers that may be sold as food or used for value-added processing. Due to potential toxicity caused by cyanogenic glycosides, elderberry is rarely eaten raw; however, it is a familiar ingredient in syrups, jams, teas, cordials, and other products.

On the commercial scale, most elderberries incorporated in products manufactured in the US contain either imported European elderberries or American elderberries. As a wild subspecies, there are currently no established cultivars of Western blue elderberry, and its utilization has existed outside modern breeding efforts to enhance genetic uniformity of traits such as yield, flavor, fruit size, or consistent ripening. However, there is interest in harvesting Western blue elderberry flowers and berries on a small-scale for value-added processing. In 2019, a market survey of California food retailers, herbalists, and specialty food producers underscored this commercial potential, with the majority of respondents finding insufficient Western blue elderberry supply and stating a strong desire to purchase California-grown *(38)*. As the market expands for the Western blue elderberry, so does the need to provide guidance to small-scale growers and processors on how to properly mitigate food safety risks.

Small-scale processors encounter challenges in implementing food safety practices for various reasons. These barriers can include awareness of food safety practices and regulations, limited access to educational resources, and financial constraints *(6, 18)*. Similarly, work has shown that small-scale growers also encounter challenges in implementing food safety management practices *(10)*. Those engaged in providing food safety communications to small-scale processors identified a need to increase awareness of food safety requirements. To address this knowledge gap, it has been recommended to develop food safety educational programing to meet the specific needs and learning styles of this stakeholder group with the aim of increasing their implementation of food safety practices *(18)*. For effective targeted food safety training, educators need to understand the production landscape, common practices, and clientele preferences in information sources and delivery modalities to effectively enhance learning outcomes and behavior changes *(10, 12)*.

Here we conducted a needs assessment to determine current practices and knowledge gaps for small-scale elderberry growers and processors related to food safety. Through the needs-assessment survey and conversations with Western blue elderberry growers and processors, we formulated key areas of need for information sharing and identified priorities for development of a training program. Building upon existing food safety training programs, we also identified two food safety risks specifically related to the Western blue elderberry, cyanogenic glycosides and Western blue elderberry pH, which required inclusion in a food safety training program specific for this audience. Based on this information, a food safety program was developed to enhance food safety knowledge and practices among this niche group of small-scale food processors. The food safety training program developed incorporated lecture, hands-on learning activities, and peer-to-peer information sharing which has been suggested to enhance learning outcomes and behavior change among small-scale growers and processors *(10)*.

MATERIALS AND METHODS

Western blue elderberry production and processing-needs assessment survey

To understand current practices related to Western blue elderberry production and processing practices, a survey tool was administered using Qualtrics. The survey contained 43 questions in multiple-choice and open-ended format *(Table 1)*. Questions focused on six topic areas including: 1) general information related to the participant's experience working with elderberries and elderflowers; 2) methods for drying and evaluation of dried elderberries and/or elderflowers; 3) methods for freezing and evaluation of frozen elderberries and/or elderflowers; 4) types of other value-added products manufactured from elderberries and/or elderflowers; 5) practices for packaging and storing dried, frozen, or value-added products derived from elderberries and/or elderflowers; and 6) food safety practices employed and/or

food safety regulations adhered to. The survey questions were reviewed by five individuals with expertise in food safety and elderberry production, as well as an Extension evaluation specialist prior to dissemination. Additionally, it was piloted with three elderberry growers/small-scale processors. The research protocol was reviewed by the Institutional Review Board (IRB) at the University of California, Davis and was deemed Exempt (IRBNet package no. 1626375-2).

The targeted participants were both elderberry/elderflower growers and processors. The survey was shared via email to a listserv of individuals engaged in previous projects related to elderberry cultivation (432 recipients total). The survey was also posted on six elderberry-related groups on Facebook, with combined membership totaling over 1,000 individuals. The survey was completed anonymously. Survey data was collected between June and September 2021.

Prior to analysis, data was reviewed for any abnormalities that would suggest the same individual responded to the survey multiple times, such as identical typed text responses from different survey participants. The responses for participants that completed the survey multiple times were removed from the dataset and not included in the analysis. Overall, 61 individuals consented to participate in the survey and a total of 49 individuals completed the final demographic question. If a single response (only one answer able to be selected) applied to that question, a percentage was calculated based on the number of respondents for the question. If multiple responses were able to be selected, the frequency of that response was compared to the total number of respondents for the question to determine the percentage of the respondents that selected each multiple-choice option.

Development of workshop content

Based on the results of the needs-assessment survey and scoping conversations with elderberry growers and processors, the team developed content for in-person workshops "Elderberry harvesting, handling, and processing: interactive workshop on best practices for food safety." Broadly, the workshops covered food safety practices for elderberry harvesting and post-harvest handling, elderberry value-added processing, and regulatory implications. The workshop content was framed around areas of interest as indicated by the needs assessment survey and scoping interviews with elderberry growers and processors. This included harvesting, post-harvest handling, value-added processing, and regulatory compliance. The workshop included hands-on activities (harvesting, post-harvest handling, value-added processing), lecture content (food safety for value-added processing, drying technologies, and key parameters for safety and quality evaluation, food safety regulations) *(Table 2)*. Prior to executing the workshops, elderberry syrup and drying trials were conducted to determine the optimal parameters for utilization in the workshop (data not shown). In 2024, organizers added to the workshop a demonstration of a post-harvest washing procedure using a sanitizer and UC ANR Master Food Preservers (MFP) to facilitate an elderberry jam making activity. In addition, participants engaged in peer-to-peer learning opportunities with a panel featuring elderberry processors who shared about their experience bringing elderberry products to market.

Development of workshop evaluation

The evaluation approach was based on the KASA/I, which focuses on short term program outcomes including change in knowledge, attitudes, skills and aspiration/intentions *(28, 32)*. Based on workshop content, a retrospective pre-/post-learning evaluation was developed to assess increases in knowledge related to key food safety concepts covered during the workshop. Participants were asked to rate their level of understanding of key concepts both before and after attending the workshop on a scale of 1 to 10 (1—no knowledge; 3— I am aware of the topic but can't explain anything about it; 5—can describe the basics on the topic; 7—know enough to teach the basics to another farmer; 10—expert). The mean and standard deviation were calculated for each question and paired t-test were used to determine significant differences between pre and post workshop results ($p < 0.05$). To assess the intention to change behaviors, an open-ended free response question was used to determine what if any new practices were intended to be implemented based on learnings from the workshop. General workshop evaluation questions were included to determine participant satisfaction with the workshop content and delivery. Demographic questions were also included in the evaluation.

Participants were recruited from the already existing elderberry grower/processor email list and elderberry Facebook groups (> 1000 individuals). Due to their participatory nature, each workshop was capped at 20 participants. Registration and waitlists for all four workshops totaled 133 individuals, indicating strong interest in the topic. In August 2023, a total of 20 individuals attended the one-day in person workshop. In August 2024, the workshop was held at the same site as in 2023, with 16 participants in attendance.

RESULTS

Needs-assessment outcome data

All respondents indicated they were currently growing elderberries (n=61) *(Table 1)*. A total of 45 respondents for the needs-assessment survey indicated they were currently processing either elder fruit or flowers. Of those processing elderberries and elderflowers, 69% (n=31 of total 45 that responded to the question) were making a formulated product (i.e., jams, syrups, teas) with berries and/or flowers, 53% (n=24 of total 45 that responded to the question) dried berries and/or flowers, 73% (n=32 of total 45 that responded to the question) froze berries. When participants were asked

TABLE 1. Western blue elderberry production and processing needs-assessment survey questionnaire

Block 1: General Information

Question	Responses
1. How are you currently working with elderberries or flowers? (select all that apply) *(multiple responses allowed)*	• Growing • Harvesting • Washing • Drying • Freezing • Value-added processing (jams, syrups, teas, etc.) • Selling • Home-use only • Other (please specify)
2. Do you purchase elderberries/flowers from outside sources? (i.e., not grown/harvested yourself) *(single response)*	• Yes • No • Sometimes • Don't know/not sure

Block 2: General Food Safety

Question	Responses
3. Which of the following would you be interested in/benefit from? (select all that apply) *(multiple responses allowed)*	• Learning about best practices on harvesting and handling for elderberries and/or flowers • Learning about best practices on drying methods for elderberries and/or flowers • Learning about best practices on freezing methods for elderberries and/or flowers • Workshop on value-added processing under CA Cottage Food Law • Workshop on value-added processing under CA Processed Food Registration • Preventive Controls Qualified Individual training • Produce Safety Alliance Grower training • I'm not sure, but I'm interested in food safety generally • Other (please specify) • None of the above
4. Are you covered under any of the following regulatory schemes for your product(s)? (select all that apply) *(multiple responses allowed)*	• Cottage Food Law • Processed Food Registration • FSMA Preventive Controls for Human Food Rule • FSMA Produce Safety Rule • Don't know/not sure • None of the above • Other (please specify)

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TABLE 1. Western blue elderberry production and processing needs-assessment survey questionnaire (cont.)

Block 2: General Food Safety

Question	Responses
5. Do you carry any 3rd party food safety audits/certifications? *(single response)*	• No • Yes (please share 3rd party auditor if you're willing) • Don't know/not sure
6. Do you have any of the following food safety practices, programs, or policies in place for your operation? (select all that apply) *(multiple responses allowed)*	• Standard employee hygiene practices • Cleaning and sanitation schedule • Environmental monitoring • Standard operating procedures for processing • Batch numbers or lot codes • Other (please describe) • Don't know/not sure • None of the above

Block 3: Drying

Question	Responses
7. How do you dry your elderberries and/or flowers? (select all methods you use for each form of the plant) *(multiple responses allowed)*	• Sun drying • Solar drying/solar dehydrator • Commercial dehydrator • Home-scale dehydrator • Oven • Cabinet dryer (on shelves) • Tunnel dryer (continuous) • Drum dryer • Freeze dryer • I work with a co-packer for this processing step • Other (please specify) • None of the above
8. How do you decide when the drying process is complete? (select all that apply) *(multiple responses allowed)*	• Monitor temperature and time • Visual appearance • Measure water activity • Measure moisture content • Measure pH • Measure Brix • Other (please describe) • None of the above
9. Do you apply/add sulfur to your dried product(s)? *(single response)*	• No • Yes/sometimes (please share when and how it is applied)
10. Do you apply any other preservative(s) to your dried product(s)? *(single response)*	• No • Yes/sometimes (please share when and how it is applied)

Continued on the next page.

TABLE 1. Western blue elderberry production and processing needs-assessment survey questionnaire (cont.)

Block 3: Drying

Question	Responses
11. What method(s) do you use to package your dried product(s)? (select all that apply) *(multiple responses allowed)*	• By hand • Mechanical • Other (please describe) • Not applicable
12. If you maintain inventory, how do you store your dried product(s)? (select all that apply) *(multiple responses allowed)*	• In retail packaging • In bulk packaging • Other (please specify) • Not applicable

Block 4: Freezing

Question	Responses
13. How do you freeze your elderberries and/or flowers? *(single response)*	• Cabinet/chest freezer • Continuous freezers • Refrigerator freezer • Liquid nitrogen • I work with a co-packer for this processing step • Other (please specify) • None of the above
14. How do you decide when the freezing process is complete? (select all that apply) *(multiple responses allowed)*	• Monitor temperature and time • Visual appearance • Other (please describe) • None of the above
15. What method(s) do you use to package your frozen product(s)? (select all that apply) *(multiple responses allowed)*	• By hand • Mechanical • Other (please describe)
16. If you maintain inventory, how do you store your frozen product(s)? (select all that apply) *(multiple responses allowed)*	• In retail packaging • In bulk packaging • Other (please specify) • Not applicable

Block 5: Other types of value-added processing

Question	Responses
17. What types of value-added products do you make from elderberries and/or flowers? (select all that apply) *(multiple responses allowed)*	• Jams • Jellies • Syrups • Cordials • Tinctures • Teas • I work with a co-packer for this processing step • Other (please specify) • None of the above

Continued on the next page.

TABLE 1. Western blue elderberry production and processing needs-assessment survey questionnaire (cont.)

Block 5: Other Types of Value-Added Processing

Question	Responses
18. What methods do you use to package your value-added product(s)? (select all that apply) *(multiple responses allowed)*	• By hand • Mechanical • Other (please describe)
19. If you maintain inventory, how do you store your value-added product(s)? (select all that apply) *(multiple responses allowed)*	• In retail packaging • In bulk packaging • Other (please specify) • Not applicable

Footnote: Total participants engaging with each Block of questions are as follows. Block 1, General Information: n=61; Block 2, General Food Safety: n=33; Block 3, Drying: n=19; Block 4, Freezing: n=32; Block 5, Other types of value-added processing: n=31. All questions within the block may not have been relevant to all participants, so individual responses rates for each question are provided within the text.

to indicate applicable regulatory schemes (e.g., Cottage Foods, FSMA, etc.) the selections with the greatest number of responses were "Don't know/not sure" (27%, n=9 of total 33 that responded to the question) and "None of the above" (27%, n=9 of total 33 that responded to the question), indicating that there is a need for food safety education within this target audience.

For those individuals drying elderberries and elderflowers the type of drying processes utilized included: outdoor solar drying (n=5 of total 19 that responded to the question), home-scale food dehydrator (n=10 of total 19 that responded to the question), cabinet dryer/commercial dryer (n=8 of total 19 that responded to the question), and freeze dryer (n=1 of total 19 that responded to the question). To assess completion of the drying process respondents relied on monitoring temperature and time (n=7 of total 19 that responded to the question) and visual appearance (n=18 of total 19 that responded to the question). No respondents monitored moisture content or water activity. Additionally, 95% of respondents (n=18 of total 19 that responded to the question) packaged dried elderberries and elderflowers by hand. Equipment used to freeze elderberries included cabinet/chest freezers (n=20 of 32 that responded to the question), refrigerator freezer (n=9 of 32 that responded to the question), and continuous freezer (n=3 of 32 that responded the to question). Freezing completion was assessed by monitoring temperature and time (n=11 of 29 that responded to the question) and visual appearance (n=17 of 29 that responded to the question). Of the 31 participants that were making formulated products from elderberries and elderflowers, syrup (n=28), cordials (n=22), teas (n=21), and tinctures (n=16) were the most commonly manufactured, followed by jams (n=9) and jellies (n=8).

Workshop evaluation

Nineteen individuals completed the retrospective pre-/post-assessment to evaluate learning outcomes for the workshop in 2023 *(Table 3)*. Across all content areas, there was a significantly higher self-reported level of knowledge after attending the workshop as compared to prior to attending the workshop ($p < 0.05$). The mean pre-test score for knowledge across all content areas was 5.23±2.41 and the post-test score was 7.33±1.17, with participation in the workshop resulting in an overall increase of 2.10±1.76 *(Table 3)*. Participants were asked to provide additional feedback through three open response questions. When asked if any new food safety concepts or practices were learned during the workshop, 15 participants responded yes, with most sharing an example, including sanitizing (n=6), processing (n=3), harvesting (n=3), and freezing (n=2).

A similar evaluation was conducted among participants in the 2024 workshop with one additional food safety concept added in the retrospective pre-/post-assessment section *(Table 4)*. Thirteen complete responses were received, and participants reported a significantly higher score in all food safety concepts after the workshop ($p < 0.05$). The mean pre-test score for knowledge across all content areas was 4.37±2.63 and the post-test score was 7.63±1.63, with a resulting overall increase in food safety knowledge of 3.26±2.15 *(Table 4)*. Due to slight differences in workshop content between 2023 and 2024, a two-sample *t*-test was conducted to determine whether the 2024 workshop

TABLE 2. Overview of elderberry workshop agenda and food safety concepts covered

Agenda item	Food safety concepts covered
Elderberry harvesting activity (campus student farm)	• Scouting for animal activity • Not harvesting dropped produce • Harvest tools and bin sanitation
Post-harvest washing of elderberry demonstration (campus student farm)	• Post-harvest water quality standard • Single pass vs. batch water • Use of sanitizers in post-harvest water
Lecture on food processing	• Safety concepts during drying • Safety concepts during freezing • Processing to reduce levels of cyanogenic glycosides • Food regulations
Practitioner panel	• Sourcing elderberries • Business development • Applying for food business licenses
Pilot Plant tour and equipment demonstration	• Types of drying equipment and how they operate • Cleaning and sanitation
Elderberry destemming activity (campus Pilot Plant)	• Importance of removal of stems, leaves, and unripe berries to reduce cyanogenic glycoside risk • Destemming by hand • Destemming using equipment
Syrup or jam making activity (campus commercial kitchen) and Cottage Food Law lecture	• Role of added sugar to reduce water activity • California Cottage Food Law • 21 CFR Part 150

TABLE 3. Knowledge increases in participants attending elderberry workshop hosted in 2023

Content area	Pre (Mean)	Post (Mean)	Difference
Strategies for minimizing food safety risks during harvest	5.53 ± 2.21	7.37 ± 1.60	1.84 ± 1.31*
Strategies for minimizing food safety risks during post-harvest	5.45 ± 2.19	7.32 ± 1.72	1.87 ± 1.25*
Difference between cleaning and sanitizing food-contact surfaces	6.03 ± 2.32	7.42 ± 1.70	1.39 ± 1.63*
Strategies for minimizing food safety risks during storage	5.58 ± 2.28	7.26 ± 1.55	1.68 ± 1.81*
Strategies for minimizing food safety risks when making value-added products	4.84 ± 2.25	7.03 ± 1.64	2.18 ± 1.57*
pH scale relevance to shelf-stable/preserved foods	4.32 ± 2.27	7.11 ± 2.05	2.79 ± 1.85*
Equipment and approaches for destemming elderberries	5.16 ± 2.83	7.68 ± 1.52	2.53 ± 2.19*
Average across all content areas combined	5.23 ± 2.41	7.33 ± 1.70	2.10 ± 1.76

Footnote: n=19; pre- and post-data presented as mean ± 1 standard deviation; Difference presented as mean ± 1 standard deviation; *denotes statistically significant difference comparing pre-test to post-test data ($p < 0.05$).

TABLE 4. Knowledge increases in participants attending elderberry workshop hosted in 2024

Content area	Pre (Mean)	Post (Mean)	Difference
Strategies for minimizing food safety risks during harvest	4.15 ± 2.48	7.46 ± 1.60	3.31 ± 1.49*
Strategies for minimizing food safety risks during post-harvest	4.38 ± 2.37	7.62 ± 1.55	3.23 ± 1.58*
Difference between cleaning and sanitizing	5.15 ± 2.96	7.69 ± 1.98	2.54 ± 2.13*
Strategies for minimizing food safety risks during storage	5.46 ± 2.87	7.69 ± 1.54	2.23 ± 1.89*
Strategies for minimizing food safety risks when making value-added products	4.69 ± 2.33	7.69 ± 1.49	3.00 ± 1.47*
Selecting and using sanitizers for washing produce	3.77 ± 2.97	7.23 ± 1.89	3.46 ± 2.24*
pH scale relevance to shelf-stable/preserved foods	4.54 ± 2.90	7.54 ± 1.60	3.00 ± 2.66*
Equipment and approaches for destemming elderberries	3.54 ± 1.78	7.92 ± 1.33	4.38 ± 2.40*
Equipment and approaches for drying elderberries	3.62 ± 2.02	7.85 ± 1.46	4.23 ± 2.22*
Average across all content areas combined	4.37 ± 2.63	7.63 ± 1.63	3.26 ± 2.15

Footnote: n=16; pre- and post-data presented as mean ± 1 standard deviation; Difference presented as mean ± 1 standard deviation; *denotes statistically significant difference comparing pre-test to post-test data ($p < 0.05$).

yielded better learning outcomes. The total difference in learning outcomes for each workshop was compared and the one–tailed *p*-value was 0.0014, indicating a statistical improvement in overall learning outcomes among the participants in the 2024 workshop. However, the mean pre-test score among participants in 2024 was lower compared to 2023, indicating the populations had differences in their incoming food safety knowledge prior to attending the workshop.

The final open-ended question aimed to assess the intention to change any behaviors or practices based on learnings from the workshop. Out of 18 total responses to this question in 2023, twelve indicated an intention to implement new strategies including enhancing documentation, improving cleaning and sanitizing, and optimizing storage and drying practices. Five respondents indicated intentions to change strategies related to planting/growing elderberries after attending the workshop. In the 2024 workshop, eleven participants responded to this question. Eight of them also noted they intended to incorporate the concepts learned during the workshop into their practices, such as sanitizing tools, washing elderberries, revising current Standard Operating Procedures (SOPs), and sharing food safety knowledge with their communities. Two attendees also considered adding more elderberries products to their businesses.

Participants indicated high satisfaction with the elderberry practitioner panel which allowed participants to ask questions of individuals currently running an elderberry value added product business. The hands-on activities were also highly valued, and participants expressed interest in more hands-on activities in future workshops. Participants were also asked about topics of interest for additional learning, with multiple selections permitted. Among the 53 responses collected from 17 participants, five individuals expressed interest in elderberry/elderflower harvest; nine in elderberry/elderflower post-harvest; eight in elderberry/elderflower drying; and six in elderberry/elderflower freezing. Nine participants expressed interest in learning more about preserving/value-added product making; five in Produce Safety Alliance (PSA) Grower Training, and three in Preventive Controls Qualified Individual (PCQI) Training. Lastly, eight attendees selected "other," specifying interests in propagation, pruning, tree care, and freeze-drying.

DISCUSSION

Previous works have shown that growers producing valued added products find themselves knowledgeable of food safety risks and consider it a priority in running their business *(10, 31)*. However, while food safety knowledge and food safety as a priority in the business are prevalent among these stakeholders, this does not always result in the implementation of food safety practices *(10, 11, 25)*. Small-scale producers and processors have indicated that standardized food safety training, such as those covering the Food Safety Modernization Act Preventive Controls for Human Food or Produce Safety Rule, are perceived as being targeted to larger scale operations and they find difficulties in applying learning to their small-scale operations *(10, 11)*. Thus, numerous works have highlighted the need to develop

training programs specifically targeting small-scale food businesses *(10, 11, 18, 19)*.

Cotter et al., 2023 outlines "food safety training culture dimensions" that defines a hierarchy of Stages with increasing effectiveness in creating behavior change in food safety trainees *(12)*. Stage 4 within these dimensions is "predict" and the elderberry food safety training program integrates much of what is outlined in this schema. This includes "targeted training based on specific needs based on analysis", "learning objectives are based on analysis of needs", "training materials integrate multimedia and hands on activities to engage participants", "training delivery facilitates situated/social interactions", "learning environment is comfortable – participants can fully engage with the content", "trainer(s) and/or learning design and development team is qualified through past experience and education encompassing both the food safety subject matter as well as training skills" *(12)*. A needs assessment identified the most common types of value-added processing utilized by small-scale elderberry/elderflower processors in California. A majority of those making value-added products either grew and/or harvested their own Western blue elderberries for inclusion in the products being manufactured versus purchasing the berries. Through interfacing with elderberry professionals, the study team also gleaned important information on current practices in relation to elderberry harvesting, post-harvesting handling, and processing. With this information, a tailored food safety workshop covering harvesting, post-harvest handling and processing was developed for a niche audience, elderberry/elderflower growers, harvesters, and processors. The workshop format integrated lecture based, peer-to-peer, and hands on learning activities. Overall, participants in the two workshops held over two subsequent summers had increased learning outcomes in all food safety concepts covered in the workshops.

Overall knowledge related to minimizing food safety risks during harvest, post-harvest operations, and storage increased in participants attending the workshop. Moreover, participants had increased knowledge related to selecting and using sanitizers in produce wash water and on produce food contact surfaces. Knowledge also increased among participants in the difference between cleaning and sanitizing food-contact surfaces. A study evaluating food safety practices on small farms found that only 39% of farmers (n=226) reported sanitizing food contact surfaces and only 33% cleaned transport containers (harvest bins) between uses *(21)*. Though long term behavior change was not evaluated in this work, participants indicated intentions to develop new Standard Operating Procedures related to cleaning and sanitizing after attending the workshop.

While there are many potentially health-promoting compounds present in elderberries, the plant also produces cyanogenic glycosides which are phytotoxins. Broadly, cyanogenic glycosides are produced by various species of plants (>2000 species) as a defense against predation *(15)*. When plant tissues are damaged, cyanogenic glycosides are released and undergo enzymatic hydrolysis (primarily via endogenous β-glucosidases) to produce hydrogen cyanide. Sambunigrin, the cyanogenic glycoside identified in elderberries to date, was discussed during the workshop. The levels of these compounds have been shown to be elevated in both the leaves and stems of the elderberry plant, so the workshop provided information on how to destem berries efficiently to reduce risk *(1, 23, 29, 30)*. Knowledge increases were observed among all participants in the types of equipment and other approaches that may be used for destemming elderberries. There is evidence that thermally processing European elderberries and other crops known to contain cyanogenic glycosides can reduce the amount to safe levels for consumption *(14, 33)*. Data on the reduction of these compounds via various types of processing was shared so that participants had a better understanding of how processing can also mitigate risks. However, there is a dearth of scientific studies related to the levels of cyanogenic glycosides in Western blue elderberries and elderflowers. Future work evaluating the levels of these compounds in berries and flowers harvested from plants grown in different environmental conditions is needed to better assess risk in products.

Participants reported knowledge increases in strategies for minimizing food safety risks when making value-added products and the relevance of the pH scale in the safety of shelf-stable food products in hermitically sealed containers. A study on American elderberry genotypes found the average pH of the berries to be 4.92 *(30)*. This prompted concerns related to the safety of canning elderberries under atmospheric processing conditions (such as water bath canning or pasteurization processes), as the pH is over 4.6 and would be considered a low-acid canned food *(40)*. Federal regulations require that low acid shelf-stable foods in hermitically sealed containers undergo a 12-D process to minimize risks associated with *Clostridium botulinum (41)*. This 12-D process for *C. botulinum* requires temperatures above the atmospheric boiling temperature of water, which can only be achieved under pressurized conditions (i.e., retorts and pressure canners). More recent work on Western blue elderberries harvested in Yolo and Solano counties in CA, showed the pH to be 3.66 *(34)*. Prior to execution of workshops, the pH of Western blue elderberries harvested in Yolo and Solano counties in CA during August 2023 was determined and had a measured pH of 3.58 (data not shown). These data indicate that the pH of Western blue elderberry is below 4.6, but more data evaluating impacts of growing region and environmental conditions of the pH of the Western blue elderberry would be valuable to inform canning practices.

Through engaging in pilot scale production of dried elderberries, we provided parameters of time/temperature/airspeed specific for the drying of elderberries to workshop

participants. This information is included in an Extension publication series on food safety best practices for the harvest, post-harvest handling, drying, and freezing of elderberries *(2, 3, 4, 5)*. Participants report increasing their understanding of equipment and approaches for drying elderberries. The food safety guide developed specifically for drying also includes information on the importance of measuring dryness parameters such as percent moisture or water activity to determine effectiveness of the drying process. Previous work has shown that individuals producing dried apples in home kitchens for retail sale relied on subjective parameters such as appearance or a finger test to assess product dryness *(26)*. This finding was supported by our needs assessment which indicates that most dried elderberry and elderflower processors rely on these types of parameters to assess when their product is effectively dried. Moreover, as many drying processes are not considered to be a microbial kill step, the workshop and guide highlighted the importance of ingredient sourcing and cleaning and sanitizing to mitigate food safety risks.

In a meta-analysis of food safety training programs, the majority of the studies (n=47) showed that food safety knowledge increased, however it was unclear in the study how this training impacted behaviors *(46)*. Only 28% of studies evaluated measured self-reported behaviors and only 19% measured observed behaviors *(46)*. A majority of these studies were published by academics engaged in Extension food safety work, and limitations in their training to conduct such a systematic evaluation, access to stakeholders post workshop engagement, or adequate funding for long-term data collection may contribute to the lack of data. A recent systematic review of peer-reviewed studies on food safety training programs aimed to identify training design strategies that result in behavior change among food processors *(12)*. Again, the lack of long-term learning and behavior change in such studies was identified in the 23 studies evaluated in this work *(12)*.

Within the farming community, peer-to-peer information sharing has been cited as one of the key sources of information about production and food safety management *(7, 8, 10, 25, 27)*. Moreover, recent work found that farmers interested in value-added processing trusted University Extension publications and Extension educators most highly as compared to auditors, farm peers, and farmers' market managers *(10)*. In addition to the workshop, which included practitioners (peers) and Extension educators, comprehensive food safety guides and publications related to growing elderberries in California, cultural significance of elderberry, nutrition/health benefits, and marketing of elderberries were developed and distributed to the participants in the workshop *(35, 36, 37, 39)*.

Professional instructional designers recommend formative and summative assessments within training as well as performing long-term evaluations 3–6 months after the completion of the training *(45)*. While ideally these types of assessments and long-term evaluations should occur, it can be challenging to implement with the diffuse population of stakeholders which are typically engaged in Extension education targeted to small-scale growers and processors. Participants were asked to provide information on new strategies for managing food safety they intended implement after attending the workshop. While not all participants provided information, 20 intended to implement new processes including enhancing documentation, improving cleaning and sanitizing, washing elderberries, revising current Standard Operating Procedures (SOPs), and sharing food safety knowledge with their communities. While long term evaluation of behavior change or observations of these changes were not included in the study, multiple participants indicated intention to implement new food safety processes after attending the workshop.

CONCLUSIONS

It can be challenging to draw an audience for non-certificate food safety courses *(18)*. By conducting a needs assessment and integrating multiple types of learning activities (lecture, hands-on, peer-to-peer) into a workshop targeting those growing and processing Western blue elderberries significant learning outcomes were observed among participants. This type of approach can be valuable for other sectors of the small-scale food industry which may be difficult to engage in food safety only training programs. Moreover, with unique crops like the Western blue elderberry additional research and education may be warranted to effectively mitigate food safety risks during processing.

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