Identifying challenges in the postharvest supply chain of fresh organic produce

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Abstract

The production of organic produce has been steadily increasing in the United States in recent years. The use of appropriate postharvest practices on small-acreage organic farms and urban farms is critical for minimizing postharvest losses and ensuring the safety of fresh produce. The objectives of this project were to (i) gain a better understanding of the critical needs that organic growers and industry buyers are facing regarding postharvest handling and safety of their produce (ii) identify the factors limiting produce quality, shelf-life, and microbial safety (iii) identify critical areas in postharvest handling, processing, and food safety of organic produce for targeted research, education, and extension work. A mixed methods qualitative study design was used to meet the project objectives. A national online survey was administered to organic produce growers (n=68). An asynchronous and synchronous online focus group (n=8) of organic produce growers was conducted to further explore some of the main themes from the online survey results. The results from the survey indicated that postharvest loss of fresh produce can range from 1% to above 20% of the total crop, with the most typical losses being between 1% and 5%. Growers believe that proper temperature management is the most important factor that affects postharvest quality of organic fruits, vegetables, and herbs. The sample cited that a lack of knowledge and financial constraints were the greatest barriers to adopting or improving postharvest handling practices. Similarly, low-cost solutions and infrastructure were the most-needed research needs by growers. The focus group (*n*=8) elaborated on knowledge constraints in postharvest handling, saying it was difficult to search the web and find reliable information. The focus group agreed that a central website hub that had searchable and dependable postharvest handling information would be a valuable resource to them. The results from this mixed-method approach will guide future research and extension programming with the long-term goal of providing small-acreage organic produce growers with appropriate postharvest handling practices that will reduce postharvest losses, improve food safety, and ultimately increase the availability of organic produce.

Presenter Information

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INTRODUCTION

Organic production has been one of the fastest-growing segments of U.S. agriculture in the last decade (USDA NASS, 2019). Sales of National Organic Program (NOP) certified commodities continue to grow (31% between 2016 and 2019. For organic vegetables, the increases are 27% for open-field production and 49% for protected production systems; for organic fruit, tree nuts and berries, the increase is 44% (USDA NASS, 2019). Most urban and peri-urban commercial agriculture focus on the production of fresh fruits and vegetables for local markets. As urban and peri-urban agriculture grow in popularity and are increasingly incorporated into land-use planning, there will be a need for more information about organic practices in urban environments, which hasn't been wildly explored (Lorenz, 2015).

General information about optimum postharvest handling and food safety practices for fruits and vegetables is available from several sources (Postharvest Center University of California, 2022; UVM Extension Ag Engineering, 2022). There are currently no known organic postharvest handling guidelines, curriculum, or training to educate organic produce growers or supply chain actors on how to effectively and safely handle fresh organic fruits, vegetables, and herbs. Improving postharvest handling from farm to fork can reduce losses and maintain quality to improve economic outcomes of farming and increase organic produce availability so as to improve the economic sustainability of their enterprises.

There is currently no data on postharvest loss or postharvest quality issues of organic produce on farms or in the supply chain. The use of synthetic fungicides and pesticides is restricted in organic crop production and postharvest storage of organic produce (Organic Food Production Provisions, 2022), which could result in more pathogens in the field and during storage. Whether and how these disease and pest management practices influence postharvest quality and shelf-life is poorly understood. Direct marketing approaches employed by small and organic producers, such as Community Supported Agriculture (CSA) and farmers' markets, create a new set of challenges in postharvest handling and storage. Growers that are taking products directly to consumer markets may not believe optimum storage techniques are valuable due to their short "storage" time on the farm. Furthermore, the cropping diversity seen on many organic produce farms amplifies the complexity of storage needs, which may make these technologies appear less accessible to growers.

Providing small-acreage organic produce growers, including urban growers, with appropriate postharvest handling practices can ensure the quality, shelf-life and safety of their products. These efforts will aid growers in reducing postharvest losses and increase the availability of organic produce at the point of sale. For such tools to be effective, they must be practical, credible, and cost-effective. An online survey and focus group study was conducted to (i) gain a better understanding of the critical needs that organic growers and industry buyers are facing with regard to postharvest handling and safety of their produce (ii) identify the factors limiting produce quality, shelf-life, and microbial safety in the postharvest chain and (iii) identify critical areas in postharvest handling, processing, and food safety of organic produce for targeted research, education, and extension work.

MATERIALS AND METHODS

Survey instrument

This project utilized online surveys and a focus group to meet project objectives. The online survey was conducted anonymously and electronically through Qualtrics from January 10th, 2022 through February 28th, 2022. Separate surveys were developed for our two target audiences: organic produce growers and industry buyers of fresh organic produce. Due to low response rates among commercial produce buyers, only the results from the grower's survey will be discussed here. To participate, growers must have produced fresh fruit, vegetables, nuts, or herbs and be NOP certified or were planning to become certified. The survey was developed by the project team with input and pretesting from an advisory board of growers, extension personnel, and organic retail professionals. The surveys included a combination of multiple choice, Likert scale, ranking, and open-ended questions covering five major topic areas: 1) Farm demographic, operation, and business information 2) Current postharvest and food safety practices 3) Questions about postharvest loss 4) Questions about their barriers and opinions on postharvest handling and, 5) Information source preferences.

To better understand current postharvest practices in use by growers and/or interest in adopting practices, respondents were asked to check if they were a.) currently using b.) not using c.) not interested in using d.) interested in using, or e.) the practice was not applicable to their crops. The practices listed were related to cooling, rinsing, microbial reduction, and packaging. To get an idea of average postharvest losses on organic farms, respondents were asked to estimate the percentage of postharvest loss for their five most economically important crops. A ranked question was used to determine the greatest barriers growers face in regard to adopting or improving postharvest handling and food safety practices on their farms. The barrier options were: financial, physical infrastructure, lack of knowledge, inadequate labor, logistical, and regulatory. An 'other' category was provided for participants to write in any additional barrier.

Three open-ended questions were asked to better understand (a) the grower's perspective on what postharvest handling practices affect product quality the most and (b) what research they think needs to be done to address postharvest safety and quality issues for fresh organic produce

and (c) what fruit, vegetable, nut, or herb researchers should focus on to reduce postharvest loss.

Advertisements for the survey were completed through appropriate farming-based email listservs and organic-focused conferences. To incentivize the questionnaire, a $10 gift card was offered to all survey participants through the Rewards Genius Tango Card platform.

There were approximately 16,585 organic produce farms in 2017 (USDA NASS, 2019). We estimated our target population size of organic produce growers as 25,000 because we also wanted to capture growers who were "planning to become NOP certified." To achieve a 95% confidence level with a 10% margin of error, 96 grower responses were needed.

Focus groups

Focus groups consisted of online asynchronous discussion boards and a synchronous zoom meeting with participants. Participants were recruited through the email list of individuals that completed our organic grower survey. The authors chose topics to focus on for the focus group based on the results from the online survey. Prompts and discussion points used during the focus groups can be found in Table 1. The inclusion criteria for participation were: 1) They were growing fresh fruit, vegetables, nuts, or herbs and 2) They were NOP organic certified, planning to become certified, or not certified but using organic practices. The focus group began with a multi-day asynchronous online forum, where participants answered written prompts and commented on one another's posts. Focusgroupit.com (FocusGroupIt, LLC, Rochester, NY) was used to facilitate the online discussion forum and participants were given an anonymous username for posting. The discussion board was followed by a 90-minute synchronous focus group over zoom.

Table 1. Organic produce grower focus group prompts and discussion points.

Online discussion board prompts
• Day 1: Participants were presented with the results on the ranked barriers to adapting or improving postharvest handling practices from the questionnaire and asked what their thoughts or reaction were to these results. • Day 2: We all know the importance of food safety and have a shared desire to keep consumers safe. How do you weigh the risk and rewards of implementing food safety practices and balancing that with produce quality in your farming and postharvest operation? • Day 3: Where do you currently get information about postharvest handling and food safety? What topics do you wish you could find more information on and how would that information benefit your farm?
Synchronous focus group discussion points
• Decision-making processes in adopting new postharvest or food safety practices or changing your current infrastructure and processes. • Opinions/reactions to postharvest technology research topics • Information format preferences

Data analysis

We did not reach our sample size goal for the online survey for growers (n= 68), so the results cannot be accurately extrapolated to be representative of the organic produce grower population in the United States. Therefore, the results of the survey are presented as a summary of the surveyed sample. Open-ended survey questions and focus group transcripts were analyzed qualitatively using content analysis with NVivo software (Release 1.6.1). Open coding was used to link reoccurring topics and identify themes relevant to project objectives.

RESULTS

Survey

1. Farm demographic information.

There were 68 responses included in the final analysis of the grower survey. Responses were collected from 30 states. 42 responses were from growers who were USDA-certified organic, while 26 indicated they were planning to become certified organic. Farm size was collected by asking for annual revenue from fresh produce. Figure 1 provides the farm size distribution from our sample. When asked to choose which best described their farm operation, 60% of respondents grew produce only, 26% had separate produce and animal production (animals excluded from produce areas at all times), 12% selected integrated produce and animal production (animals allowed in produce production areas at certain times), and the remaining chose "other." Most growers (96%) cited that they had more than one major market. The most popular markets from our sample were farmer's markets, grocery stores, on-farm stands, and restaurants. The growers were asked to list their five most economically important crops. From the sample, 28% of the respondents listed three or fewer crops, while the majority listed four or five important crops. Tomatoes, cucumbers, and peppers were the most common economically important crops listed. The majority of participants were either qualified exempt from the Food Safety Modernization Act Produce Safety Rule (40%) or were not sure if they were exempt or covered (33%).

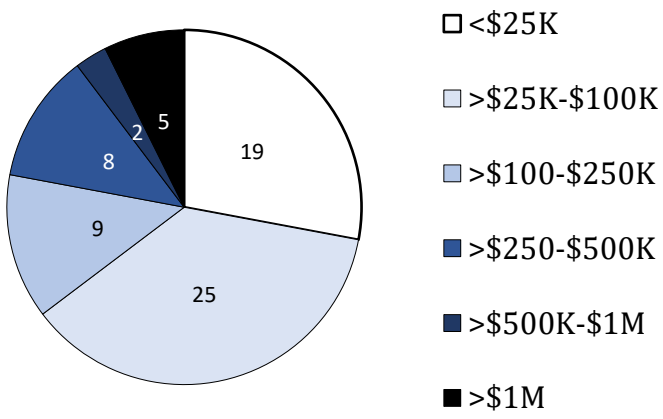

Figure 1. Surveyed sample farm size estimated by the annual revenue of fresh produce from a nationally distributed survey of organic produce growers.

2. Current postharvest practices.

The current cooling and rinsing practices being used by the survey participants can be found in Figures 2 and 3, respectively. Some practices differed based on farm size. For instance, farms with a revenue of $25k or higher in fresh produce were more likely to use forced air cooling or hydro cooling. The most-used cooling practice among all participants was room cooling. The largest percent of participants "interested in using" a cooling practice was for hydro cooling (36%) and forced air cooling (27%). For large farms (>$100K-1M), 50% rinsed with potable water, while only 35% indicated rinsing with Organic Materials Review Institute (OMRI)-approved sanitizers, and 32% with chorine-based sanitizers. For the smallest farm sizes, rinsing with OMRI-approved sanitizers was more common than rinsing with potable water or chlorine-based sanitizers. Among all respondents, 36% also indicated they would be "interested in using" OMRI-approved sanitizers, and 33% cited interest in chlorine-based sanitizers for rinsing.

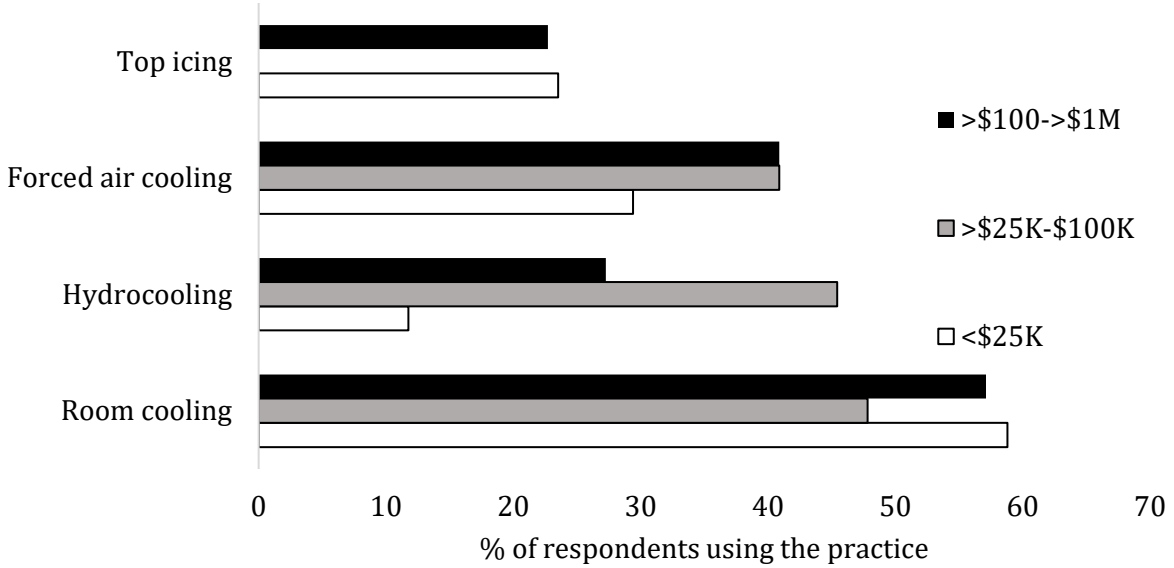

Figure 2. Cooling practices currently used by respondents in different farm size categories (revenue from fresh organic produce) from a national survey of organic produce growers.

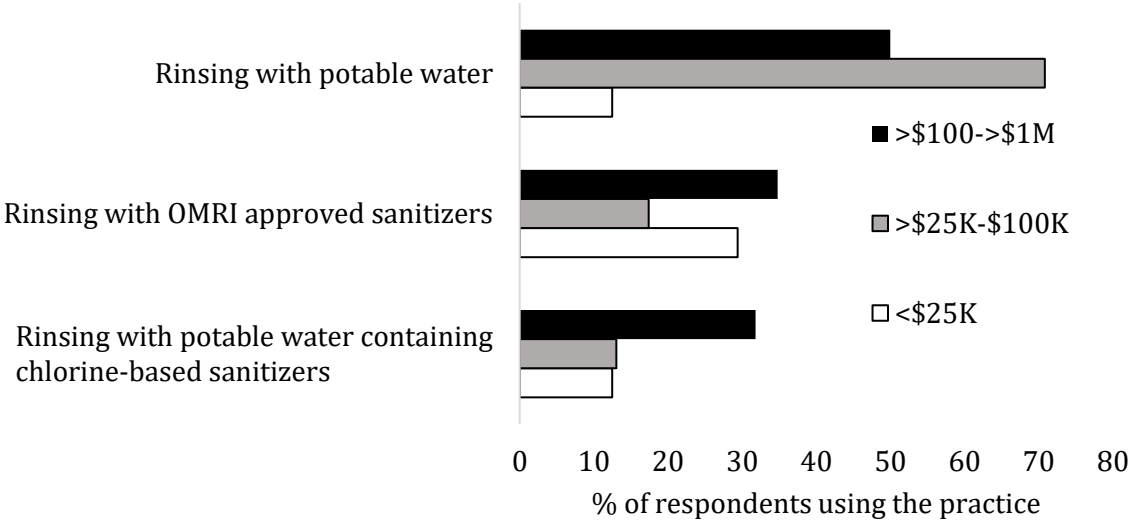

Figure 3. Rinsing practices currently used by respondents in different farm size categories (revenue from fresh organic produce) from a national survey of organic produce growers.

3. Postharvest loss.

Respondents were asked to estimate the postharvest loss of each of their five most economically important crops. The question also included an optional write-in portion to provide additional feedback about postharvest losses. The majority of responses (64%) estimated that their

postharvest loss was between 1 and 10 % (Figure 4a). The most cited crops were mixed leafy greens (*n*=23), small fruits (*n*=23), and tomatoes (*n*=22). Similar to the distribution of postharvest loss for all crops, the leafy green postharvest loss was estimated to be between 1-10% by 70% of the responses. However, for tomatoes, the estimated loss skewed higher, with half of the respondents estimating they lost 1-10% of the crop and the other half estimating their postharvest losses were 11% and higher (Figure 4b). Two growers with postharvest losses between 1 and 10% for leafy greens used the write-in option to explain that their losses remain low because "greens are harvested 24 hours before sale, so there is little time for decay" and "losses are reduced by serving local markets with frequent deliveries." On the other hand, a few growers with higher postharvest loss (11% and higher) explained that it was due to a "lack of infrastructure such as a walk-in cooler and automated greens washer," "not having adequate storage conditions," and not having refrigeration or postharvest storage because of high start-up costs. There was also one mention of high postharvest loss for tomatoes (11-25%) due to challenges in training labor on grading standards.

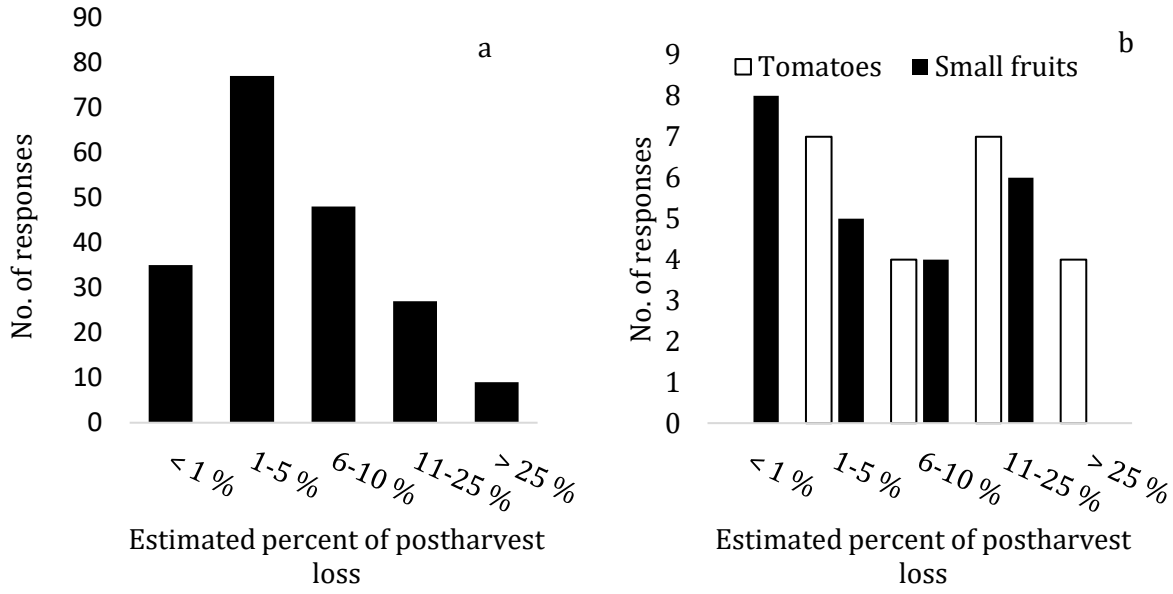

Figure 4. (a) Estimated percent of postharvest loss for all crops listed by organic grower survey participants. (b) Estimated percent of postharvest loss of tomatoes and small fruits.

4. Barriers and opinions on postharvest handling and quality.

Growers were asked to rank a set of barriers to adopting or improving postharvest handling practices. The greatest barrier differed based on farm size, which was determined by the annual revenue of organic produce. For small farms, (< $25K) the top two barriers were 'Financial' and 'Physical Infrastructure'. For farms with annual revenue from produce between $25K and $100K, the top two barriers were 'Financial' and 'Inadequate Labor'. For larger farms (>$100K->$1M), the top two barriers were 'Lack of Knowledge' and 'Inadequate Labor'. From the full sample, the top three barriers were 'Financial', 'Lack of Knowledge', and 'Inadequate Labor

Table 2 provides the most-mentioned responses to the open-ended question that asked "From your experience in the organic produce industry, what is the most important practice that

affects postharvest quality?" The most-mentioned practices were related to temperature management. Table 3 provides a summary of the answers to the open-ended questions "What research do you think needs to be done to address postharvest safety and quality issues for fresh organic produce?" Low-cost solutions for postharvest infrastructure and processes, and research related to preharvest quality issues (disease, pests, etc.) were the most-cited responses. When asked what product researchers should focus on to reduce postharvest loss, tomato was listed the most (*n*=13), followed by berries (*n*=5).

Table 2. Most-mentioned practices from the open-ended question: "From your experience in the organic produce industry, what is the most important practice that affects postharvest quality?"

Practice	**Total mentions**[z]
Temperature	21
-Proper storage/cold chain	
-Cooling	
Handling conditions	3
Not selling all of harvested crop	3
Packaging	3
Preharvest factors	3
Sanitizing/surface treatments	3
Humidity	2
Quality at harvest	2
Time	2

[z]Total number of mentions per theme from the open-ended question in an online survey of organic produce growers.

Table 3. Most-mentioned themes from the open-ended question: "What research do you think needs to be done to address postharvest safety and quality issues for fresh organic produce?"

Research themes	**Total mentions**[z]
Low-cost solutions/affordability	7
Preharvest factors	7
Infrastructure	6
Optimal storage environments	6
Education	5
Packaging	5
Shelf life extension	4
Optimize harvesting	3
Transportation optimization	3
Sanitation	3

[z]Total number of mentions per theme from the open-ended question in an online survey of organic produce growers.

5. Preferred information sources.

When asked what their preferred ways to receive industry or technical information, participants selected demonstrations, webinars, and websites most frequently (Figure 5).

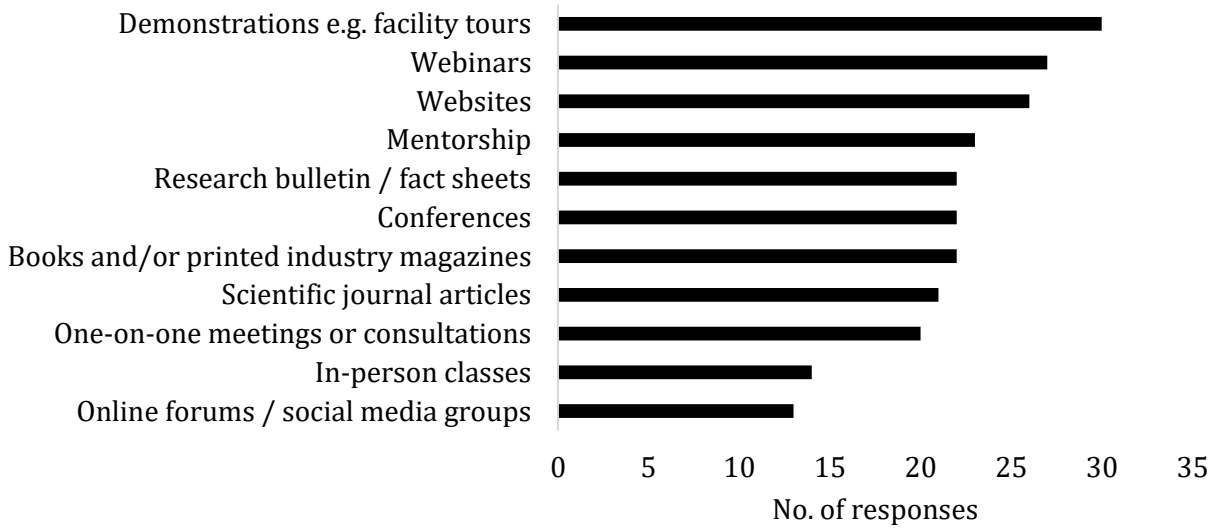

Figure 5. Grower-preferred methods for receiving industry or technical information from a nationally-distributed organic grower survey.

Focus group

1. Demographics.

Seven growers participated in the asynchronous discussion board, while only five were able to participate in the synchronous video conference call. One participant who participated in the conference call did not contribute to the asynchronous discussion board, so the total sample size for the focus group was 8 people. The participants were located in Kansas (*n*=1), Minnesota (*n*=2), Tennessee (*n*=2), Illinois (*n*=1), Washington (*n*=1), and Massachusetts (*n*=1). Three participants were NOP-certified organic, two were planning to become certified, and three were not planning to become certified, but were using organic practices. Among the focus group participants, garlic, tomatoes, pepper, mushrooms, herbs, and cucumbers were the most commonly grown crops. The participants represented a spectrum of farm sizes. Three participants made less than $25K in annual sales of fresh organic produce, four participants made between $25K and $100K, and one participant made between $100K and $250K.

2. Asynchronous discussion board.

All discussion board participants agreed that financial and knowledge barriers were the largest barriers for organic growers to adopt or improve postharvest practices, and provided further explanations as to why these are barriers in their farming operations (Table 4).

Table 4. Discussion board themes on the largest barriers facing organic growers in adopting or improving postharvest handling practices.

Barriers	Themes
Financial	• Difficult to budget for large postharvest equipment • Time and labor investments included in the financial barrier
Lack of knowledge	• Difficulty finding reliable information • Time-intensive and difficult to search the web • Not knowing what questions to ask • Difficult to find information about cost-effective postharvest equipment

The discussion board prompt on day 2 resulted in common themes about incentives for good on-farm food safety. Firstly, all of the participants mentioned that good food safety is very important for consumer confidence. Additionally, three responses also linked improved produce safety and quality to a higher price point in the market. One grower stated, "I have seen first-hand the increased confidence of my customers and the financial rewards from having verifiable food safety measures that tell my customers that I truly do care about providing safe food that is of higher quality for them and members of their family." Two growers also linked better food safety practices to the prolonged shelf life of their produce.

On day 3 of the discussion board, growers listed information that they would find helpful to their postharvest operation and farm. Most of the information needed was general guidelines on harvesting, handling, and postharvest storage conditions for small-scale production. The following list is all of the needed resources mentioned by the focus group participants.

- Good/Better/Best or low/medium/high-cost guides for choosing postharvest equipment and practices.
- Quality scales (2 mentions)
    - Certified organic quality scales and up-to-date best practices for postharvest activities
    - Quality scales and what produce looks like at different points in the postharvest life (harvest, handling, treatment, storage, shopping, retail).
- Detailed harvest and postharvest handling practices to achieve optimal produce quality. There is a lot of information on this for tomato (e.g. Picking ripe for direct market but underripe for long-distance travel/storage). But, there is interest for similar information for less obvious crops.
- Prep and presentation guides of produce for specific markets with achievable standards based on farm size/scale.
- Database has specific handling instructions for individual varieties of fruits and vegetables.
- Cold storage solutions for small-scale operations that grow a wide variety of products that have different cold storage requirements.

- Guides for harvest efficiency that allow for higher productivity and larger quantities.

When asked where they currently get information about postharvest handling, the seven participants listed online searches (two mentions), university extension (2 mentions), YouTube, Online blogs, state Department of Agriculture, state organic inspector, NOP recommendations, and USDA offices for food safety practices.

3. Synchronous focus group meeting.

During the live focus group, participants were asked to explain their decision-making processes in regard to adapting or changing their postharvest processes and infrastructure. Three out of four growers that responded to the question said they made decisions based on their markets. One grower explained how they installed three coolers in their on-farm store when they switched from selling at farmer's markets because they couldn't find adequate labor. Now, they sell 75% of their produce at the on-farm store. The largest-scale grower in the focus group discussed how selling in wholesale markets and getting the required food safety certifications guided their packinghouse decisions and changes: "A lot of our harvest packhouse decisions are coming from meeting standards for food safety inspections. So, Gap and GHP and in the future, Primus. But you know, we've had a food safety person from K-State that can help you through some of those steps and act as an auditor and walk through and inspect. And that has definitely helped our farm take those next steps and be able to sell wholesale. You know, I've kind of got budgeted every year, ten thousand dollars in packhouse realignment, which is for, you know, even an operation of our size, a fairly significant figure." The third market-driven decision comment had to do with how their postharvest handling differs between two different customers: "I do a lot of my postharvest handling for restaurants or grocery stores and restaurants, who want everything very clean, very sanitized, trimmed, ready to go. Of course, they pay a premium for that. Making sure to snap off green beans, that sort of thing. But I have found when I go to my farmer's market, carrots, for example, I don't make them nice and clean and shiny if there's little soil hanging on them. I have found people actually like that."

The focus group was presented with a list of postharvest technologies and asked for their opinions on the technologies and what information they would need to implement a new technology in their operation. One participant had a negative reaction to the technologies, saying that "when you say the word technology, the hair on the back of my neck goes up. I have a feeling I'm an old-fashioned type of farmer. I'm on my grandfather's farm. I like to farm the way he did. If he didn't have a UV light treatment, something or, then I don't need it either." Two participants were interested in sustainable/alternative packaging options, and one cited an issue in finding sustainable and affordable packaging options that meet food safety requirements. Lastly, one grower was interested in the UV light treatment, especially if it could be set up on their current conveyor line. The growers mentioned they would need return on investment information and details about how the technology is used for specific crops before deciding if it would be useful to them.

Lastly, the participants were asked how they would want to receive information. The answers from the 5 participants were as follows:

- PDFs in a database and webinars for more technical information.
- Recordings you can play back later when you are not pressed for time during the season.
- A bank of best practices that have been vetted by a scientist and are region-specific.
- Issues arise during the season, and you don't have time to research them. Need for a simple way to get questions answered at a central website.

- Searchable database of PDFs with multiple regional extension resources.

DISCUSSION

The goal of this project was to better understand the current state and critical needs in the postharvest handling and food safety operations of organic produce growers. The online recruitment and delivery of the survey and focus group could have contributed to our low response rates and biased the study toward growers more active online and in farming-related online communities. In many rural areas, infrastructure does not provide adequate bandwidth and rural residents report lower daily use of the internet than their urban and suburban counterparts (Vogels, 2021). Therefore, our sample may underrepresent rural organic growers and populations that abstain from internet use, such as the Amish.

Our low response rates among industry buyers of fresh organic produce may have been due to a hesitation to share private company information. Many of our buyer survey responses could not be used for analysis due to a large number of incomplete answers. The length of the survey was also longer than the grower survey, which could have led to more incomplete responses.

Although these results cannot be reliably extrapolated to the wider population of organic produce growers due to a low response rate, the information gleaned can help postharvest and/or food safety extension professionals and researchers better understand the challenges facing organic growers in the postharvest handling of their crops. The majority of participants reported relatively low percentages of postharvest loss (1 and 10 % of harvested crop). The highest postharvest losses were reported in soft-fleshed produce like tomatoes and small fruits. Optimal tomato storage temperatures range from 7 °C to 15 °C depending on the maturity stage and cultivar (Suslow and Cantwell, 1997). Most fruits and vegetables grown on small, diversified farms require lower storage temperatures, which makes it challenging for growers with only one cold room. Cold storage solutions for operations that grow a wide variety of crops was a specific resource need cited by a focus group participant. A common theme throughout the survey and focus group was the difficulty in budgeting for postharvest infrastructure, like cold storage, which creates a barrier in improving postharvest quality and food safety. Interestingly, there were no comments from growers that indicated their postharvest loss issues were directly related to NOP restrictions or a lack of OMRI-approved postharvest treatments. The barriers were more related to small-scale farming in general, with growers not having enough time, capital, and labor to gain the appropriate knowledge and integrate optimal postharvest infrastructure. Similar constraints (costs, time, and limited knowledge and resources) have been reported for a lack of on-farm food safety compliance (Chen et al., 2021). Future research and outreach should focus on efficient, low-cost postharvest solutions with detailed return-on-investment information.

Growers were well aware that optimal temperature management was one of the most critical factors affecting postharvest quality and shelf-life. Pre-cooling to remove field heat is an important practice to maintain quality. However, less than half of the survey participants reported using these cooling methods, and usage was lower among the smallest farms. A survey among small to medium-sized direct-to-consumer growers in Georgia, South Caroline, and Virginia also found that room cooling was the most commonly-used cooling practice (Harrison et al., 2013). One day of shelf life can be lost with every one-hour delay in cooling (Elansari et al., 2019). Therefore, proper temperature management directly after harvest can help provide a longer shelf-life during the distribution and consumer stages, where the majority of fresh fruit and vegetable losses occur (Gustavsson et al., 2011). Respondents to our survey were interested in using these cooling practices, pointing to the further need for outreach to small organic farms on the benefits of proper

temperature management—even when selling in direct-to-consumer markets where the time between harvest and sale is often short.

The importance of good food safety was unanimous among the focus group participants. Each had the desire to produce safe, nutritious food for customers. The survey aimed to assess current food safety practices through questions about animals in their farming operation, rinse water sanitizer use, and food safety modernization act status. The sample indicated higher use and interest in the use of OMRI-approved rinse water sanitizers than chlorine-based sanitizers. Although chlorine sanitizers for rinse water are allowable under the NOP with restrictions, these results could indicate organic growers may be more likely to adopt the important food safety practice of postharvest water sanitization using alternative OMRI-approved sanitizers. Only a small number of farms integrated animals into their production fields. It is key that farmers have the appropriate food safety training to recognize risks associated with livestock fecal contamination to safely integrate animals into production fields. The large number of growers who were not sure if they were qualified exempt from the Food Safety Modernization Act Produce Safety Rule, could indicate they have not attended a grower training through the Produce Safety Alliance. Continual outreach on the importance of farm food safety, even for very small organic farms, remains necessary.

Many of the information and research needs mentioned by our survey sample and focus group are currently available through various extension websites. Although it is often not organic-specific information. For instance, the University of California Davis Postharvest Technology Center has a searchable database of articles and fact sheets for many individual products. There are also a number of handbooks and resources that provide information about small-farm postharvest solutions, including low-cost cooling and storage available for free online (Kitinoja and Kader, 2015; Suslow, Mitchm, and Cantwell, 2015; UVM Extension Ag Engineering). Further research is needed to determine if organic produce growers either find current resources on postharvest handling insufficient, inapplicable to their farming operations, or simply do not have exposure to these sources when conducting internet research. Considering knowledge was one of the main barriers to adopting or improving postharvest handling and food safety, university extension and outreach on the topic are not sufficiently meeting the needs of organic produce growers. A 2018 survey asked vegetable and berry growers of various sizes about the availability of information and knowledge on postharvest-related topics, and 58% of the sample thought availability was low availability (Callahan, 2019). Our grower focus group was in consensus about the need for a central website hub where they could search for postharvest information appropriate to their operations. If a new postharvest-related information website was developed, an extensive outreach plan based in sound agriculture communication theories would be necessary to ensure the resource is accessible and applicable to organic produce growers around the country.

Our national sample of organic growers indicated they prefer to receive information through facility tours, webinars, websites, and mentorship. Callahan (2019) similarly asked vegetable and berry growers what sources they use for postharvest-related information. The top answers were extension, conferences, web research, and experience (apprentices/early career) (Callahan, 2019). The results from our study and Callahan (2019) indicate that small and midsized produce growers (organic and non-organic) still value in-person training (i.e., facility tours, conferences, mentorship, and apprenticeships), which is consistent with previous reports (Lewis Ivey et al., 2012; Ngathou et al., 2006), but also points to a shift in growers utilizing more web-based resources. Again, the survey outreach methods used in our study and Callahan (2019) were through online listservs, which could bias answers towards a more web-savvy audience.

CONCLUSION

This study utilized a nationally distributed survey and online focus group to investigate the current needs in postharvest handling of organic produce growers. The growers in our sample did not attribute any specific quality or postharvest loss concerns to organic farming or the NOP standards. The crops with the highest reported postharvest loss were tomatoes and small fruits. The main barrier to adopting or improving postharvest and food safety practices was financial limitations that prevent the investment of postharvest equipment, cold storage, and labor. Secondly, organic growers need more easily-accessible educational resources for best postharvest practices. Specific areas of research and outreach include; the importance of cooling, guides on postharvest handling for tomatoes and berries, low-cost postharvest technology and equipment solutions for diversified farms, and return-on-investment information for equipment and technology. This information will also be valuable to urban produce growers, who are often small-scale and sustainability-minded. Future research efforts should prioritize farmer participatory research (Snapp et al., 2019) to ensure that new postharvest processes and equipment are appropriate and meet the diverse, site-specific needs of organic produce growers or urban growers. It is still unclear if organic produce has quality, spoilage, or postharvest loss issues further along the supply chain, so continued efforts to engage with industry buyers of organic produce remains necessary.

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