PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 45, No. 5, p. 340–352
https://doi.org/10.4315/FPT-24-061

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

Autumn Stoll[1] and Yaohua Feng[1*]

[1]Department of Food Science, Purdue University, 745 Agriculture Mall Dr, West Lafayette, IN 47907, USA

Bridging the Gap by Listening to the Needs: A Multi-State Survey and Interview Study for Military Veteran Farmers in the United States

ABSTRACT

Military veteran farmers constitute a niche group who encounter unique barriers in obtaining food safety education. Previous research has shown that food safety training can achieve better outcomes when materials are tailored to the intended audience. This study used a combination of qualitative (interviews) and quantitative (surveys) data collection to identify the on-farm food safety practices and resource needs of U.S. military veterans who are farmers. An online survey was administered nationwide in March 2023. The survey was distributed using a list of military veteran farmers through the Farmer Veteran Coalition. The interviews consisted of in-person interviews conducted on a multi-state level in 2022–2023 at regional and national agricultural conferences. A total of 550 survey participants were included for analysis and 28 interview participants. The survey indicated only 51% of participants previously had received food safety training. Both the survey and interviews identified barriers to accessing food safety training, for example a lack of time, lack of information and limited technology. The survey reported format preferences for on-farm food safety education were email (n = 343, 62%), in-person workshops (n = 337, 61%) and online videos (n = 308, 56%). These findings will guide the development of food safety educational materials for military veteran farmers.

INTRODUCTION

Fresh produce continues to gain public attention due to various foodborne illness outbreaks that have occurred throughout the United States. For example, in 2016, a multistate Listeriosis outbreak linked to packaged salad products affected people in nine states, and resulted in 19 hospitalizations and one death *(5)*. During a three-month span in 2022, consumption of cantaloupe contaminated with *Salmonella* sickened 87 people, 32 of whom were hospitalized *(40)*. Farmers play a critical role in ensuring the safety of food entering the supply chain. However, owners of small-scale farms face challenges in meeting food safety standards, such as additional costs necessary to meet those standards, lack of help on the farm, or deficits in food safety knowledge *(3, 7, 14, 16, 17)*. Furthermore, owners of small-

*Author for correspondence: stoll149@umn.edu; Yaohua Feng, yfengchi@purdue.edu

sized farms face barriers to accessing food safety information; for example, one study found that owners of small farms considered the amount of information overwhelming, and that they didn't have enough time to access food safety education *(6)*. Thus, owners of small-sized farms struggle to meet food safety standards.

The United States has more than 370,000 military veteran farmers, of which most have small-sized farms with less than $25,000 in agriculture product sales *(38)*. Military veterans often experience physical and/or invisible disabilities, such as post-traumatic stress disorder (PTSD), or traumatic brain injury (TBI) *(23)*. These individuals may face challenges when returning to civilian life due to their disabilities and being away from civilian life for several years. Farming can be very therapeutic for veterans. Often referred to as "Green Care," farming has been used as an effective tool to boost mental and physical health, as well as improving cognitive abilities *(4, 12, 28, 31)*. A study by Fleming assessed the impact of farming on military veterans of post-9/11 wars found that farming provided both mental and physical benefits to those veterans *(13)*. Thus, farming is an attractive and beneficial therapeutic activity for military veterans.

To better understand the on-farm food safety needs of military veteran farmers, Chen et al. *(8)* conducted a pilot study with military veteran farmers in Indiana. The study highlighted that military veteran farmers were aware of food safety, but that they lacked the critical knowledge to perform recommended on-farm food safety practices. This study identified education barriers among military veteran growers' on-farm food safety needs using the Theory of Planned Behavior and provided insights into their demographics, farming practices, and preferred formats to develop tailored and effective training programs. The objective of our study is to assess the U.S. military veteran farmers' on-farm food safety knowledge, behaviors, and attitudes toward food safety education to recommend tailored training, identify barriers, and provide insights into future training topics and delivery formats.

MATERIALS AND METHODS

This study used a combination of qualitative (interviews) and quantitative (surveys) data collection approaches. Conducting interviews enables researchers to gather a range of thoughts and in-depth understanding on a topic of interest *(10, 15)*, while surveys allow researchers to gather data about a specific population and conduct statistical tests *(28, 29)*. The Institutional Review Board at Purdue University has approved and reviewed the protocol for this study (IRB# 1807020834).

Interview design and analysis

The interview script was adapted from a previous study of military veteran farmers by Chen et al. *(8)*. The structured interview questions consisted of four major topics: (i) experiences with value-added businesses, (ii) motivators and barriers to starting and expanding value-added businesses, (iii) prior food safety training experiences, and (iv) preferred education topics and information delivery formats (Appendix).

We recruited participants in person at AgrAbility National Training Workshop (Spokane, WA) and AgrAbility Regional Training Workshop – Veterans in Agriculture (Indianapolis, IN). Only participants who were military veteran farmers were eligible to participate in this study. Between March and June 2023, two trained researchers conducted 28 interviews, a moderator led the interviews following a predeveloped script, and a co-moderator took notes during the interview. Interview recruitment concluded once information saturation was met *(18)*. They recorded all interviews and saved the files on an encrypted cloud storage platform. Demographic information was collected from interview participants via an online survey, however only 23 out of the 28 interview participants completed the survey. Each participant was compensated US $50 for their time in participating in the interview.

Two trained researchers completed the qualitative coding analysis using NVivo 14 (Burlington, MA) software. A main researcher developed codes, and an assistant researcher checked the codes throughout the process for accuracy. For consistency, the study used methods described in The Coding Manual for Qualitative Researchers for coding *(32)*. For the first code cycles, we developed descriptive, process, and emotional codes, and then constructed the second code cycle categories using the pattern coding method. Finally, we combined categories into common themes, and the final codebook was reviewed and approved by the primary project researcher (Appendix).

Survey design and analysis

The study's survey questions were adapted from previous on-farm food safety need assessments *(8, 30, 35, 36)*. The survey questions were reviewed internally and then externally by two experts in the field and two members of the Farmer Veteran Coalition. Researchers made revisions and conducted a pilot test with 10 military veteran farmers for flow and face validity. They made final revisions to the survey before conducting data collection. We acknowledge some questions developed from the current study could be improved for use in future studies.

The survey was divided into six sections, including 1) screener questions; 2) farming background; 3) value-added product; 4) theory of planned behavior; 5) food safety knowledge for produce growers; 6) food safety practices for produce growers; 7) food safety education needs; 8) unique needs of veteran farmers; and 9) demographics. The full survey can be found in Appendix. The survey was administered in March 2023 through Qualtrics (Provo, UT). The survey was distributed nationwide using a list of military

veteran farmers through the Farmer Veteran Coalition. A $50 incentive fee was randomly distributed to one out of every 10 survey participants.

To assess military veteran farmers' on-farm food safety behaviors, we used the theory of planned behavior (TPB) model to develop a series of 12 questions *(1)*. The TPB is a model used to predict an individual's specific behavior based on four constructs: 1) attitude; 2) perceived behavioral control; 3) subjective norms; 4) behavioral intention *(1)*. Attitude is how the individual feels towards the behavior. Subjective norms are the perceived attitudes of those in the individual's social group toward a specific behavior. Perceived behavioral control is how much an individual feels they have control over acting out a specific behavior. Behavior intention is defined as an individual's intention to act out a specific behavior *(1)*. Participants were asked to rate how much they agreed with statements regarding the four TPB constructs, ranging from strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree. We adapted question style and TPB construct statements from studies by Chen et al., *(7)*, Rezaei et al., *(30)*; and Soon & Baines, *(36)*. See Appendix for the full set of statements.

To assess on-farm food safety knowledge of produce-growing military veteran farmers, we asked 13 true or false questions and one multiple-choice question related to produce safety. To assess on-farm food safety behaviors, we asked 10 questions; however, not all questions were shown based on survey flow. The survey included six "yes or no" questions, three "select all that apply" questions, and one multiple-choice question (Appendix). We developed the questions based on FSMA PSR *(39)*.

We used IBM Statistics SPSS version 29.0.2.0 (IBM, Armonk, NY, USA) for descriptive and statistical analysis of the survey data. We calculated mean rating scores for the TPB questions and the reliable source questions. We calculated attitude scores by assigning scores of 1 to 5 to the 5-point Likert scale (strongly agree = 5, strongly disagree = 1) and taking the average of the assigned scores for each statement. We calculated mean scores of trusted sources by applying the average of the assigned scores (extremely unreliable = 1, somewhat unreliable = 2, neither reliable nor unreliable = 3, somewhat reliable = 4, extremely reliable = 5) for each source. We used a paired sample t test to determine whether the differences between trusted sources perceived by the participants were statistically significant. A McNemar paired proportion *t*-test enabled us to ascertain whether the differences in food safety training status and on-farm food safety behaviors were statistically significant. We used the Spearman's rho test to determine the correlation between the TPB constructs *(2)*. We discerned statistical significance at the level of 0.05 for all tests.

RESULTS

Demographics and farming characteristics

In total, 558 U.S. military veteran farms participated in this study, including 550 survey participants, and 28 interview participants. *Table 1* presents the veteran farmers' demographic characteristics from the survey. Most military veteran farmers who responded to the survey and participated in the interviews were male, aged 45 and above, and identifying as white. The top motivator for both current (n = 486) and future veteran farmers (n = 64) to start farming was the benefit from physical activity stress release that farming provides, wanting to gain independent over their daily life and labor and it being an activity to spend time with their family *(Fig. 1)*.

The survey showed that most (93%) military veteran farmers who were currently farming had 1–4 employees (including themselves). Additionally, the survey and interviews demonstrated that most military veteran farmers had had been farming for 6 years or less (67%; 70%). One military veteran farmer mentioned during the interview the desire to remain a small farming operation to avoid food safety risks. The interview participants identified practices in which they engaged to ensure on-farm food safety, including following the rules and regulations, and regular cleaning and sanitation. One veteran farmer stated that staying small helped reduce the risk of foodborne illness: "We stay small for a reason...because everything can get out of control in two seconds, you know, and I just don't like that" (military veteran farmer, female).

Most military veteran farmers who took the survey and grew produce (fruits and/or vegetables) had estimated average annual produce sales for the past three years under $25,000 (80%), and had five acres or less of land dedicated to growing produce (79%). Similarly, most interview participants who grew produce had estimated average annual produce sales for the past three years under $10,000 (74%) *(Table 2)*.

Current food safety training and trusted sources

Results from the survey indicated that about half of the military veteran farmers had not received food safety training (49%). Of those who had undergone food safety training, food handling training such as ServeSafe or food handlers training was the most reported (55%). For military veteran farmers who grew fruits and vegetables (n = 254), over half (63%) reported receiving training on sanitation and hygiene. Similarly, of those who hire employees (beyond themselves), only 62% reported that their employees received training on sanitation and hygiene (Appendix).

Survey participants identified University Extension as the most reliable source of on-farm food safety information (4.19 ± .953), ranking higher than farmer peers, third-party auditors, farmers' market managers, government websites, and government inspectors ($P \leq .05$) *(Table 3)*. One military veteran farmer stated the reasoning behind trusting

TABLE 1. Sociodemographic characteristics of survey participants n = 550 interviews n = 23*

Characteristics	Survey n (%)	Interview n (%)
Age		
25–34	20 (4)	1 (4)
35–44	142 (26)	4 (17)
45–54	152 (28)	6 (26)
55–64	146 (26)	7 (30)
65 and above	79 (14)	5 (22)
Prefer not to answer	11 (2)	0
Gender		
Male	448 (81)	16 (70)
Female	91 (16)	7 (30)
Prefer not to say	11 (2)	0
Ethnicity (Check all that apply)		
White (non-Hispanic)	438 (80)	16 (70)
Hispanic	19 (3)	2 (9)
Asian or Pacific Islander	12 (2)	0
Native American	34 (6)	3 (13)
African American	30 (5)	5 (22)
Other	17 (3)	1 (4)
Prefer not to say	44 (8)	2 (9)
Military branch (Check all that apply)		
Army	263 (48)	
Navy	111 (20)	
Air Force	110 (20)	
National Guard	81 (15)	
Marine Corps	65 (12)	
Army or Air Force Reserves	47 (9)	
Coast Guard	13 (2)	

*Only including interview participants who completed the online demographic questionnaire

University Extension: "Colleges and universities are pretty much my 'go to' because they have done so much research and they have research papers on this stuff" (military veteran farmer, female).

Barriers to food safety behavior change based on the Theory of Planned Behavior

The survey applied the TPB to assess military veteran farmers' that are currently farming (n = 486) attitudes, perceived social norms, perceived behavioral control, and behavioral intentions toward on-farm food safety practices.

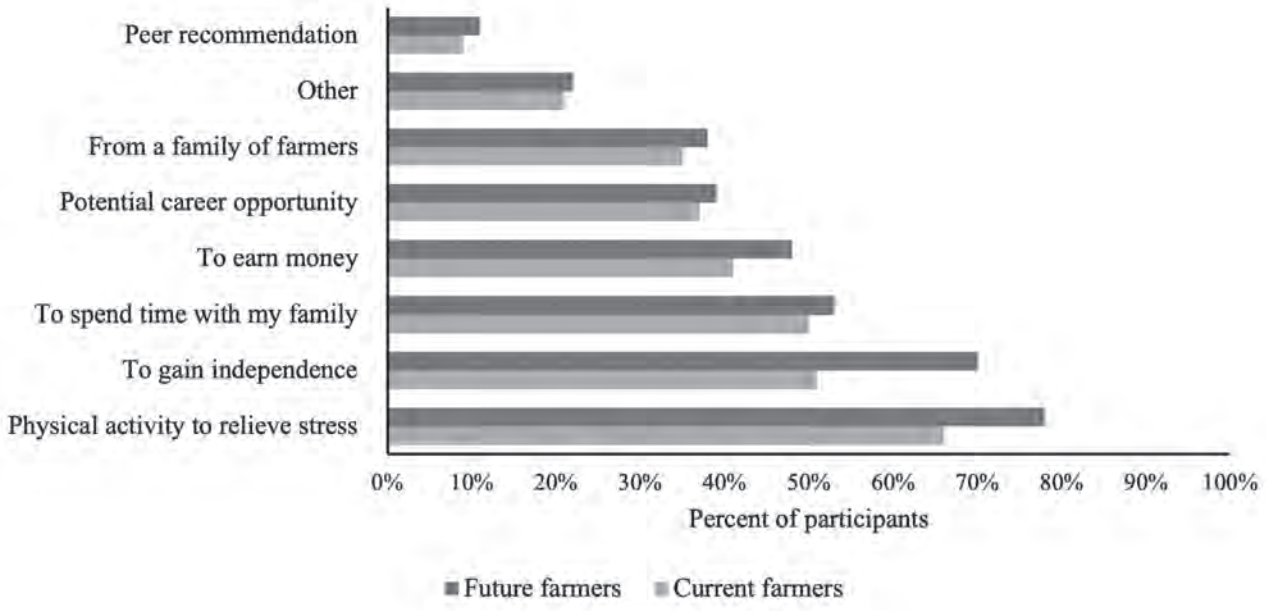

Figure 1. Military veteran farmer motivation to start farming (current farmers n = 486; future farmers n = 64).

Participants demonstrated awareness of the importance of on-farm food safety with "attitude" scoring the highest mean 4.33 ± .82 (out of five) *(Table 5)*. Attitude also had the highest correlation toward behavioral intention (0.605; $P<0.01$) over perceived behavioral control and subject norms of food safety *(Fig. 2)*. Interview participants further emphasized the importance of food safety on their farm. When asked if food safety was a top priority, almost all veteran farmers agreed that it was. Only one veteran farmer hesitated to state that food safety was a top priority for him, indicating that it more of a priority for government agencies: "I wouldn't say [food safety is a top priority of] mine, but the government… they stimulate certain things and the County Health Department sort of dictates the type of facility that you can use, and you have to have that you know that that as part of the label [indicating it was produced] in an approved facility" (military veteran farmer, male). The interview participants offered insight into why they viewed food safety as a top priority. They acknowledged the importance that food safety exerts on their business as a result of protecting consumers and avoiding punitive consequences from regulatory authorities: "Food safety is probably the top priority of any kind of business [because safety failure] can kill a business for the most part" (military veteran farmer, male).

However, "perceived behavioral control toward food safety" scored the lowest mean (3.65 ± .757). Among all participants, 57% (n = 312) perceived barriers in accessing food safety information, which they attributed to a lack of time (27%) or lack of educational materials (21%) among other impediments to accessing on-farm food safety information. In the interviews, participants also emphasized a lack of time as a perceived barrier to accessing on-farm food safety information, with some military veteran farmers mentioning technology as a barrier, due in some cases to limited internet access. Those and other barriers could all contribute to the low perceived behavioral control.

Future food safety education topics

From the survey and interview results, we identified future on-farm food safety education topics based on preferred topics of interest reported *(Fig. 3)*, knowledge scores, and self-reported behaviors.

The survey revealed that military veteran farmers are interested in learning more about soil amendments and wildlife (57%), agricultural water (48%), domesticated animals and land use (48%), and value-added products (47%). Based on the assessment of their on-farm food safety practices, food safety about soil amendments and land use should be enhanced among this audience. Among the produce growing military veteran farmers (n = 254), 11% who used manure reported using fresh manure (not composted) on their crops. Additionally, 30% reported having livestock adjacent to their produce fields.

The survey showed that 48% of military veteran farmers wanted to learn more about agricultural water safety. However, based on the survey results, this topic needs more attention. The knowledge question with the most incorrect answers (40%) from military veteran farmers who grew fruits and vegetables was whether a widely used microbial indicator, generic E. coli, was the indicator organism for

TABLE 2. Farm characteristics survey participants n = 550 interviews n = 23*

Characteristics	Survey response n (%)	Interview response n (%)
Currently Farming		
Yes	486 (88)	21 (91)
No, I am planning to start farming	64 (12)	2 (9)
Years of Farming		
I am thinking of farming	64 (12)	2 (9)
Less than 1 year	34 (6)	4 (17)
1–3 years	175 (32)	5 (22)
4–6 years	117 (21)	7 (30)
7–9 years	52 (9)	1 (5)
10 years or more	108 (20)	4 (17)
Number of Employees (n = 486)		
1	114 (23)	
2–4	340 (70)	
5–10	24 (5)	
11–20	5 (1)	
More than 20	3 (1)	
What do you currently grow or raise check all that apply (n = 486)		
Vegetables	222 (26)	11 (52)
Fruit	154 (32)	11 (52)
Mushrooms	33 (7)	1 (4)
Grains and/or cereal (e.g., corn, soybean, sorghum and rice)	52 (11)	0
Cotton	2 (1)	0
Flowers	74 (15)	0
Poultry	181 (37)	3 (13)
Eggs	240 (49)	3 (13)
Hogs	86 (18)	3 (13)
Sheep and/or goats	116 (24)	1 (4)
Beef cattle	126 (26)	3 (13)
Cows (milk)	15 (3)	1 (4)
Honey	111 (23)	6 (26)
Other	111 (23)	4 (17)
Produce grower farm size (n = 254)		
Annual produce sales survey participants		
Less than $25,000	204 (80)	-
$25,001–$250,000	26 (10)	-
$250,001–$500,000	1 (1)	-
More than $500,000	2 (1)	-
Prefer not to answer	21 (8)	-

Continued on the next page.

TABLE 2. Farm characteristics survey participants n = 550 interviews n = 23*(cont.)

Characteristics	Survey response n (%)	Interview response n (%)
Produce grower farm size (n = 254)		
*Annual produce sales interview participants***		
Less than $10,000	-	17 (74)
$10,000–$49,999	-	2 (9)
$50,000–$99,999	-	1 (4)
$100,000–$149,999	-	2 (9)
Prefer not to answer	-	1 (4)
Acres of land to grow fresh produce		
Less than 1 acre	85 (33)	
1–5 acres	113 (46)	
6–9 acres	27 (11)	
10–49 acres	25 (10)	
50–69 acres	1 (1)	
More or equal to 100 acres	3 (1)	
Location for selling farm products (n = 486)		
Farmers' markets	149 (31)	
Roadside stand	66 (14)	
Local CSA farm-share (Community Supportive Agriculture)	29 (6)	
Grocery store	30 (6)	
On-farm store	89 (18)	
Restaurants	41 (8)	
Distributor	39 (8)	
Online (e.g., Facebook, Instagram, Amazon)	144 (30)	
Word of mouth	306 (63)	
Other	112 (23)	

*Only including interview participants who completed online demographic questionnaire
**Interview participants were shown a different scale for produce sales

TABLE 3. Reliability of different sources for food safety information (n = 550)

Sources	Mean (St. Dev.)
University Extension	4.19 ± .953
Government*	3.72 ± 1.115
Government inspector*	3.62 ± 1.132
Farmers peers*	3.54 ± .994
Third-party auditors*	3.34 ± .912
Farmers' markets managers*	3.26 ± .921

*Mean scores were significantly different from variable "University Extension" $P \leq .05$

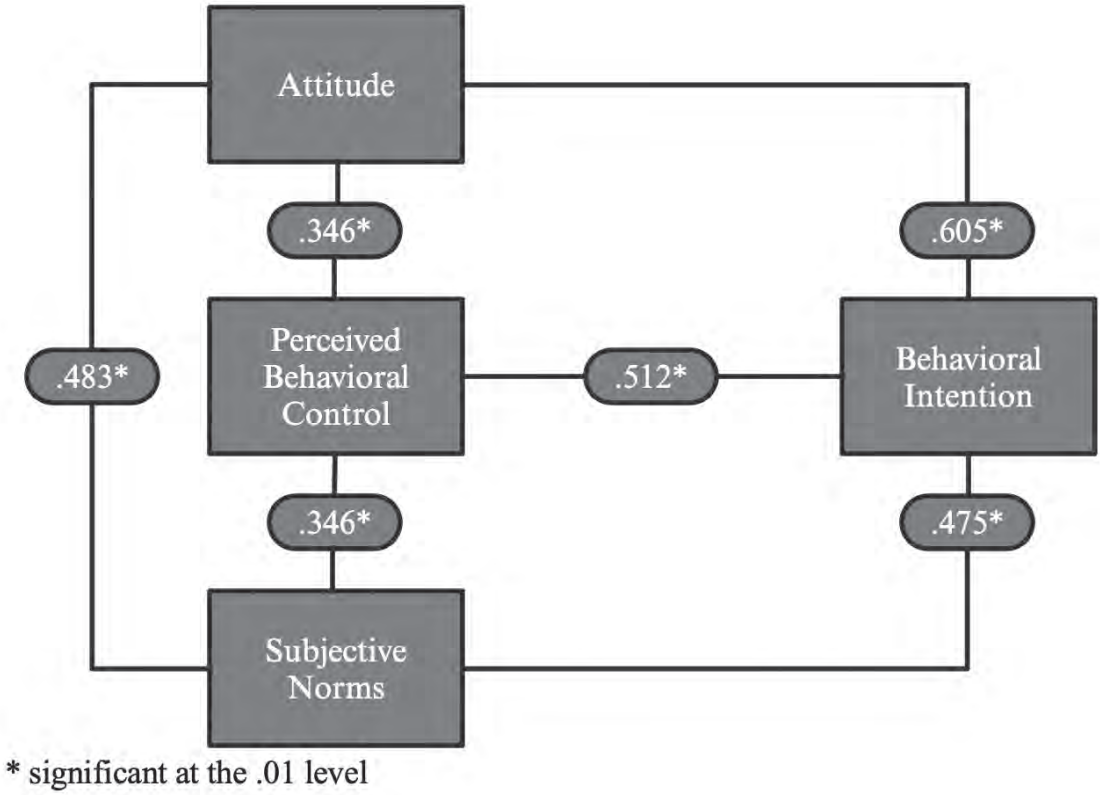

Figure 2. Theory of planned behavior—Spearman's rho correlation.

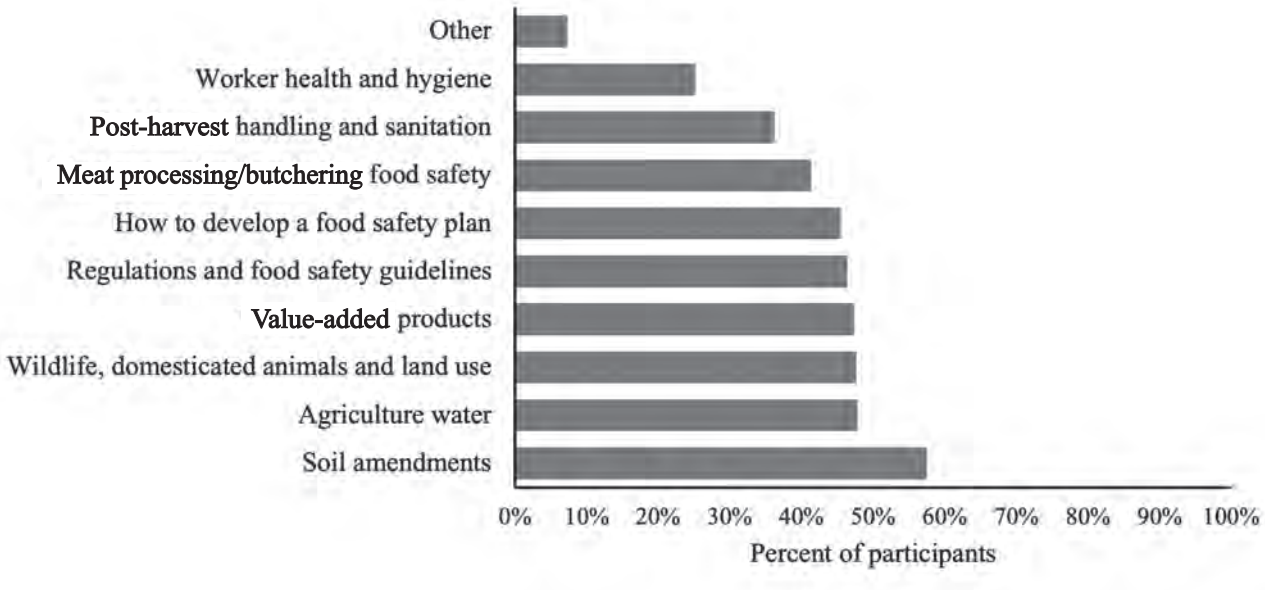

Figure 3. Preferred on-farm food safety training topics n = 550.

TABLE 4. Barriers to accessing food safety information n = 550

Barriers	Responses n (%)
Lack of time	152 (27)
Lack of educational materials	115 (21)
Too expensive	95 (17)
Overwhelming amount of information	92 (17)
The information is too complicated	28 (5)
I do not feel like the information applies to me	59 (11)
I don't have barriers	238 (43)

TABLE 5. Theory of planned behavior means scores

TPB Construct	Mean (St. Dev.)
Attitude	4.33 ± .82
Intention	4.12 ± .78
Social Norm	3.66 ± .74
Perceived Behavioral Control	3.65 ± .76

water safety (Appendix). Nearly half of produce-growing military veteran farmers reported that they do not conduct microbial testing of agricultural water (43%). The 40% incorrect answers and the 43% of military veteran farmers who did not conduct microbial testing were not significantly correlated (0.07; P=0.22).

Interview responses regarding on-farm food safety training topics indicated interest in sanitation education. For example, one interview participant mentioned agrotourism: "Sanitation and hygiene for people coming onto your farm. Not just them handling stuff, but them handling your animals and how it will affect your land, your crops, your stock" (military veteran farmer, female). Cleaning and sanitation training needs to be emphasized based on the survey results. Of the produce-growing military veteran farmers (n = 254), a total of 15% did not know that harvest bins should be cleaned and sanitized before and after harvest. A total of 11% did not clean their tools before and after harvest, and 16% did not sanitize their harvest equipment before and after harvest. Of those who did not clean or sanitize their harvest equipment, 7% and 18%, respectively, did not consider doing so as necessary (Appendix).

Future food safety education format

From the survey, military veteran farmers' top three choices for presentation of educational material were one four-hour session (35%), four one-hour sessions (26%), and two two-hour sessions (33%). The least preferred configuration was eight half-hour sessions (4%) *(Table 6)*. Their top ranked method for receiving on-farm food safety information was email (62%), followed by in-person workshops (61%), and online videos (56%). The interviews yielded more insight on preferred delivery format. A few of the farmers mentioned the term "death by PowerPoint," stating that many of their military trainings were presented through PowerPoint presentations and they considered that format too boring. For example, one military veteran farmer stated, "one of the big things in the military is they make you sit through so many PowerPoints. Most veterans do not want to look at a PowerPoint like that. They will tell you 'don't show me a PowerPoint.' I would try to avoid it if you can" (military veteran farmer, male). The interviews further explored alternative education formats—for example, virtual reality. When asked if they would be interested in a virtual reality training format, one veteran farmer who expressed excitement said, "I think that would be fun. I think it would be new. It would be exciting…Whereas with PowerPoint, you know, I had to get up and walk because you're sitting too long" (military veteran farmer, female). Another military veteran farmer who mentioned that virtual reality would be a time saver observed, "Oh, I think it would be, you know, more convenient than driving someplace, right? If it was done in a way that was just as valuable, you know, I think, you know, in military training. We always do, you know, start

TABLE 6. Education preferences n = 550

Characteristic	Response n (%)
Preferred delivery for 4 hours of material	
One 4-hour session (including short breaks)	193 (35)
Two 2-hour sessions (including short breaks)	180 (33)
Four 1-hour sessions	142 (26)
Eight half-hour sessions	24 (4)
Other	10 (2)
Preferred material delivery	
Email	343 (62)
In-person workshops	337 (61)
Online videos	308 (56)
Virtual presentations with discussion sessions	210 (38)
Guided facility tours	170 (31)
Virtual presentations without discussion sessions	98 (18)
Virtual discussion without presentation	29 (5)
Other	22 (4)
Important factors in training	
Instructors' caring demeanor, knowledge, and skills	417 (76)
Interacting with other participants and instructor	334 (61)
Hearing other participants stories	263 (48)
Supportive feedback and acknowledgment	241 (44)
Feeling supported in the groups	161 (29)
Learning communication skills	89 (16)
Telling my stories	68 (12)
Provision of shared accommodations ("quarters") and meals	63 (12)

with 'this is what you need to learn' and then 'this is how you apply it.' Virtual could be used very well for how you apply it" (military veteran farmer, male).

From the survey, most military veteran farmers (76%) selected "instructors' caring demeanor, knowledge, and skills" as important factors in training, and over half (61%) selected "interacting with other participants and the instructor" as an important factor in training. Just under half selected "hearing other participants stories" (48%), and "supportive feedback and acknowledgement" (44%).

DISCUSSION

Military veteran farmers represent a unique demographic within the agricultural community, facing distinct challenges and opportunities in their pursuit of food safety education. With most managing small-sized farms, they often lack access to tailored food safety resources. While many are motivated to adopt best practices, barriers such as limited time, inadequate information, and limited technology hinder their progress. This section explores the food safety education needs of military veteran farmers, emphasizing their preferences for training formats, the gaps in their current knowledge, and the strategies necessary to support their growth in on-farm food safety management.

Military veteran's unique attributes motivate farming.

This study found that most military veteran farmers in the United States are over the age of 45 and identify as male. These findings reflect the demographics reported in the 2022 U.S Census for military veteran farmers *(41)*. The top three most represented military branches by survey participants were Army, Navy and Airforce which aligned with the top

three most populated military branches in the United States *(11)*. Most military veteran farmers grew or raised fruits, vegetables, eggs, poultry and honey. These findings are reflected by a previous study with military veteran farmers which found fruits, vegetables, eggs and poultry as the most common items grown or raised *(8)*.

Many veteran farmers were motivated to begin farming due to the physical activity and stress release that farming offers and wanting to gain independence over their daily life. This can be explained by the current study's finding that most military veteran farmers identify as living with some level of disability. As previous studies have shown, farming offers therapeutic benefits for those living with physical and/ or invisible disabilities *(4, 12, 25)*. Interestingly, when investigating just small- sized and beginner farmers in the United States, different motivations to start farming emerge, for example pursuing farming as a lifestyle and to promote environmentally friendly and sustainable agriculture *(19)*. Thus, farming is a positive activity to help military veterans integrate back into civilian life.

High in attitudes but low in perceived behavioral control.

Most veteran farmers are motivated to commit to food safety practices, as most rated on-farm food safety being important. However, behavior change is more than motivation. The current study used the TPB as a tool to assess military veteran farmer's on-farm food safety behaviors. Attitude had the highest mean score and highest correlation towards on-farm food safety behavioral intention. Similarly, another study reported military veteran farmers having positive attitudes towards the importance of on-farm food safety *(8)*. Another study with farmers found that attitude was the most reliable indicator toward on-farm food safety intentions *(30)*. Additionally, a study conducted with small-size farmers found that attitude was positively and significantly correlated with intentions *(34)*. These studies and the findings from the current study illustrate that attitude influences veteran farmers' intentions, thus efforts to increase veteran farmers' attitude towards food safety is recommended to influence on-farm food safety behaviors. However, in contrast one study with dairy farmers found that subjective norms were the most important factor to predict on-farm food safety behaviors *(22)*.

Although veteran farmers are aware of the importance of on-farm food safety, they scored lowest in perceived behavioral control, meaning they feel they do not have the adequate knowledge or resources to perform on-farm food safety tasks. This may be explained by the military veteran farmers in the current study lack of food safety training, especially training specific to on- farm food safety practices. Further explanation can be determined from the current study by the military veteran farmers perceived lack of time, lack of information and limited technology as barriers to accessing on-farm food safety information *(Table 4)*. These findings are similar to a previous study with military veteran farmers, finding time and an overwhelming amount of information as barriers to accessing on-farm food safety information *(8)*. Additionally, studies with small-sized farmers found they often report time as a barrier to accessing on-farm food safety information *(6, 19)*. The perceived lack of information may be due to most military veteran farmers being beginner and small-sized. Thus, they feel the educational material is only applicable to larger and/more experienced farmers. Additionally, most farmers are rural and may face limited internet coverage which may impact their ability to access online material *(38)*. Furthermore, the current study identified military veteran farmers' desire to grow, diversify and/or add value-added products. These findings are supported by previous studies that found small-sized and beginning farmers are typically more inclined to incorporate value-added products due to the potential financial gain *(7, 37)*. Although military veteran farmers want to grow their business, the barriers identified in the current study may impact their ability to grow.

Veteran farmers can benefit from information on soil amendments, cleaning and sanitation, agricultural water and value-added foods.

Instead of overwhelming veteran farmers by providing all food safety topics, it is critical to offer topics that can target their interests and weaknesses, including 1) soil amendments; 2) cleaning and sanitation; 3) agricultural water; 4) value-added foods.

Soil amendments was the top reported topic about which military veteran farmers wanted to learn more. These findings were consistent with a review conducted by Chen et al. *(8)*, which identified soil amendments as one of the topmost food safety topics about which small-sized farmers needed more information. Additionally, in the current study some of the veteran farmers reported risky soil practices, such as using fresh (un-composted) manure, and having produce fields adjacent to livestock pastures. Harrison et al. *(17)* disclosed similar findings in their study of small-sized farms, which identified risky manure practices such as using fresh manure on produce. Additionally, a review by Chen et al. *(9)* indicated that many small farmers use untreated manure.

Military veteran farmers demonstrated a desire to learn more about cleaning and sanitation. Some reported risky behaviors regarding insufficient cleaning and sanitizing of harvest equipment, indicating that cleaning and sanitation is an important topic about which military veteran farmers need to learn more. In support of these findings, one study found that produce growers struggle to adhere to GAP, a program used to minimize the risk of microbial contamination *(20)*. Another study found that owners of small-sized farms failed to properly clean and sanitize harvesting equipment and surfaces *(17)*.

The knowledge scores indicated that military veteran farmers who grow fruits and vegetables have a good understanding of basic on-farm food safety; however, they may benefit from agricultural water safety education. These findings reflect previous studies which indicate small-size farmers would benefit from agricultural water management training *(17, 19, 33)*. One study of small-sized farms found gaps in their on-farm food safety practices that may put their consumers at risk for foodborne illness, specifically indicating agricultural water safety as a major concern *(17)*. Additionally, the current study revealed that just under half of military veteran farmers who grow fruits and vegetables do not conduct agricultural water microbial testing. Similarly, another study found that small-scale produce growers scored lowest in knowledge of agricultural water safety *(33)*. These findings may be attributable to the small-scale growers' status of exemption from FSMA PSR. Ensuring the microbial quality of agricultural water remains important, despite the exemption status, because agricultural water can act as a major source of contamination *(25, 26, 36, 43)*. One study with organic farmers highlighted the importance of proper agricultural water management and produce wash to prevent microbial contamination *(44)*.

Military veteran farmers indicated an interest in learning more about value-added products. Many sharing a desire to start producing value-added products. Studies have indicated a need to support small-sized farmers with value- added product by offering resources such as clarity on regulations *(6, 7)*. Supporting value-adding efforts offers famers the confidence and opportunity to grow their business *(6)*. Interestingly, a previous study with military veteran farmers did not indicate a high percentage interested in learning more about value- added foods *(8)*. The findings from the previous study may be explained by its participants residing from only one state in the United States, compared to the current study which was a national study.

Veteran farmers prefer learning via emails, in-person workshops and university extension.

The current study indicates that military veteran farmers prefer a variety of different on-farm food safety education formats, the most popular of which are emails and in-person workshops. Similarly, a previous study with military veteran farmers indicated a preference for receiving information through online newsletter and in-person workshops *(8)*. Online newsletters are very similar to email and are often distributed via email. Emails may be an attractive format for on-farm food safety information due to the limited time requirements. As the current study indicates, military veteran farmers value their time, and perceive time commitments as a main barrier discouraging them from accessing on-farm food safety information. Rural farmers also commonly encounter slow or limited internet connectivity *(42)*. Additionally, produce growers prefer to communicate in person, which may explain the desire for in-person workshops *(20)*. The current study further emphasized a desire for hands-on and innovative training that deviates from the typical PowerPoint presentation, such as virtual reality. In fact, virtual reality has been used as an effective format to administer education material across different disciplines *(21, 24)*. One study emphasized the importance of ongoing on-farm food safety training to promote retention of information and to improve confidence in practicing on-farm food safety procedures *(8)*.

The current study highlighted university extension as the most reliable source of on-farm food safety information. These findings are supported by previous studies which found university extension agencies among the most trusted sources of on-farm food safety information among produce growers *(20)*, small-scale produce growers *(6, 19)* and certified organic growers *(27)*. Additionally, the current study emphasized how important having a caring and knowledgeable instructor is for military veteran farmers. Thus, the extension agency bears the responsibility to develop and disseminate appropriate on-farm food safety resources to military veteran farmers. Additionally, the current study found military veteran farmers perceive farmers' market managers as the least reliable source for on-farm food safety information. These findings were consistent with another study that found small-scale produce growers also place little trust in farmers' market managers *(6)*.

ACKNOWLEDGMENTS

The authors thank Juan Archila-Godínez for their survey development contribution and Claudia Guillen, Elma Kontor-Manu and Suyapa Fabiola Rojas Oropel for their support in interview data collection and management. Additionally, the authors thank National AgrAbility Project and Farmer Veteran Coalition for their support throughout the project. This research was funded by the U.S. Department of Agriculture–National Institute of Food and Agriculture grant #2020-70020-33029 and #2020-70020-32263.

REFERENCES

1. Ajzen, I. 1991. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50(2), 179–211.
2. Archila-Godínez, J. C., H. Chen, L., Klinestiver, L. Rosa, T., Barrett, S. C. Henley, and Y. Feng. 2022. An evaluation of a virtual food safety program for low-income families: applying the theory of planned behavior. *Foods.* 11(3), 355.
3. Astill, G., T. Minor, S. Thornsbury, and L. Calvin. 2019. US produce growers' decision making under evolving food safety standards. U.S. Department of Agriculture, Economic Research Service. EIB 210.
4. Cacciatore, J., R. Gorman and K. Thieleman. 2020. Evaluating care farming as a means to care for those in trauma and grief. *Health Place.* 62, 102281.
5. Centers for Disease Control and Prevention. 2016. Multistate Outbreak of Listeriosis Linked to Packaged Salads Produced at Springfield, Ohio Dole Processing Facility (Final Update). Available at: https://www.cdc.gov/listeria/outbreaks/bagged-salads-0116/index.html#:~:text=A%20total%20of%2019%20people,reported%20in%20a%20pregnant%20woman. Accessed May 27 2024.

6. Chen, H., T. Benjamin, W. Guan, and Y. Feng. 2022. Food safety education needs assessment for small-scale produce growers interested in value-added food production. *J. Food Prot.* 85(2), 220–230.
7. Chen, H., J. K. Ellett, R. Phillips, and Y. Feng. 2021. Small-scale produce growers' barriers and motivators to value-added business: food safety and beyond. *Food Control.* 130:108192.
8. Chen, H., K. Gibson, and Y. Feng. 2021. Identification of food safety education needs for military veteran farmers. *Food Prot. Trends.* 41(6).
9. Chen, H., A. J. Kinchla, N. Richard, A. Shaw, and Y. Feng. 2021. Produce growers' on-farm food safety education: a review. *J. Food Prot.* 84(4), 704–716.
10. DiCicco-Bloom, B., and B. F. Crabtree. 2006. The qualitative research interview. *Med Educ.* 40(4), 314–321.
11. Council on Foreign Relations. 2020. Demographics of U.S Military. Available at: https://www.cfr.org/backgrounder/demographics-us-military. Accessed 15 December 2024.
12. Elings, M., and J. Hassink. 2008. Green care farms, a safe community between illness or addiction and the wider society. *Int. J. Ther. Communities.* 29(3), 310–322.
13. Fleming, L. L. 2015. Veteran to farmer programs: An emerging nature-based programming trend. *J. Ther. Hortic.* 25(1), 27–48.
14. Goodwin, J. N., and J. L. Gouldthorpe. 2013. Small farmers, big challenges: A needs assessment of Florida small-scale farmers' production challenges and Training needs. *J. Rural Soc. Sci.* 28(1), 3.
15. Granek, L., and O. Nakash. 2016. The impact of qualitative research on the "real world" knowledge translation as education, policy, clinical training, and clinical practice. *J. Humanist Psychol.* 56(4), 414–435.
16. Gwin, L., C. A. Brekken, and L. Trant. 2018. Farm Direct at five years: An early assessment of Oregon's farm-focused cottage food law. *J. Agric. Food Syst. Community Dev.* 8(3), 85–104.
17. Harrison, J. A., J. W. Gaskin, M. A. Harrison, J. L. Cannon, R. R., Boyer, and G. W. Zehnder. 2013. Survey of food safety practices on small to medium-sized farms and in farmers markets. *J. Food Prot.* 76(11), 1989–1993.
18. Hennink, M., and B. N. Kaiser. 2022. Sample sizes for saturation in qualitative research: a systematic review of empirical tests. *Soc. Sci. Med*. 292:114523
19. Iles, K., R. Nixon, Z. Ma, K. Gibson, and T. Benjamin. 2023. The motivations, challenges and needs of small-and medium-scale beginning farmers in the midwestern United States. *J. Agric. Food Syst. Community Dev.* 12(3), 31–68.
20. Ivey, M. L. L., J. T. LeJeune ,and S. A. Miller. 2012. Vegetable producers' perceptions of food safety hazards in the Midwestern USA. *Food Control.* 26(2), 453–465.
21. Kavanagh, S., A. Luxton-Reilly, B. Wuensche, and B. Plimmer. 2017. A systematic review of virtual reality in education. *Themes Sci. Technol. Educ.* 10(2), 85–119.
22. Ledo, J., K. A. Hettinga, J. Bijman, J. Kussaga, and P. A. Luning. 2021. A tailored food safety and hygiene training approach for dairy farmers in an emerging dairy chain. *Food Control.* 124, 107918.
23. Livingston, N. A., S. L. Farmer, C. T. Mahoney, B. P. Marx, and T. M. Keane. 2022. The role of PTSD symptom clusters and criterion in predicting future high-risk drug and alcohol use among returning veteran men and women. *Psychol. Serv.* 19(2), 386.
24. Man, S. S., H. Wen, and B. C. L. So. 2023. Are virtual reality applications effective for construction safety training and education? A systematic review and meta-analysis. *J. Saf. Res.* 88:230–243.
25. Olaimat, A. N., and R. A. Holley. 2012. Factors influencing the microbial safety of fresh produce: a review. *Food Microbiol.* 32(1), 1–19.
26. Park, S., B. Szonyi, R. Gautam, K. Nightingale, J. Anciso, and R. Ivanek. 2012. Risk factors for microbial contamination in fruits and vegetables at the preharvest level: a systematic review. *J. Food Prot.* 75(11), 2055–2081.
27. Pires, A. F., P. D. Millner, J. Baron, and M. T. Jay-Russell. 2018. Assessment of current practices of organic farmers regarding biological soil amendments of animal origin in a multi-regional US study. *Food Prot. Trends.* 38(5).
28. Ponto, J. 2015. Understanding and evaluating survey research. *J. Adv. Pract. Oncol.* 6(2), 168.
29. Radhakrishna, R. B. 2007. Tips for developing and testing questionnaires/instruments. *J Ext.* 45(1), 25.
30. Rezaei, R., S. Mianaji, and A. Ganjloo. 2018. Factors affecting farmers' intention to engage in on-farm food safety practices in Iran: Extending the theory of planned behavior. *J. Rural Stud.* 60, 152–166.
31. Rich, S. D., B. R. Hickey, and E. K. Kaprielian. 2023. Trauma Informed Farm Animal Assisted Neurotherapy and Green Care Farming for Neurodiverse Conditions. *IntechOpen.*
32. Saldaña, J. 2016. The coding manual for qualitative researchers. SAGE, Los Angeles, CA
33. Schneider, K. R., M. Schroeder, A. Gutierrez, K. Kharel, R. G. Schneider, A. Harder, A.G. Philyaw Perez, K.L. Woods, L.L. Dunn, P.V. Priyesh, C.C. Gunter, E. Rogers, C. Simmons, L.M. Johnston, C. Carter, T. M. Taylor, A. Castillo, J. R. Anciso, J. Masabani, L. K. Strawn, and M. D. Danyluk. 2024. Southern Region Produce Safety Alliance Grower Training: Using Pre-and Post-Training Knowledge Assessments to Understand Training Effectiveness. *J. Food Prot.* 87(5), 100266.
34. Senger, I., J. A. R. Borges, and J. A. D. Machado. 2017. Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. *J. Rural Stud.* 49, 32–40.
35. Shaw, A., A. Enderton, C. Strohbehn, J. Overdiep, and L. Naeve. 2018. Determining what growers need to comply with the food safety modernization act produce safety rule. *J. Ext.* 56–7.
36. Soon, J. M., and R. N. Baines. 2012. Food safety training and evaluation of handwashing intention among fresh produce farm workers. *Food Control.* 23(2), 437–448.
37. Torres, A. 2022. Exploring the adoption of technologies among beginning farmers in the specialty crops industry. *Agric. Finance Rev.* 82(3), 538–558.
38. U.S. Department of Agriculture. 2017. Census of Agriculture. Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf. Accessed 22 April 2024.
39. U.S. Food and Drug Administration. 2018. Food Safety Modernization Act (FSMA). Available at: https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma. Accessed 22 April 2024.
40. U.S. Food and Drug Administration. 2023. FDA issues report highlighting *Salmonella* outbreak in cantaloupe during summer of 2022. Available at: https://www.fda.gov/food/cfsan-constituent-updates/fda-issues-report-highlighting-salmonella-outbreak-cantaloupe-during-summer-2022. Accessed 22 April 2024.
41. U.S. Food and Drug Administration. 2024. Producers with military services. Available at: https://www.nass.usda.gov/Publications/Highlights/2024/census22_highlights_military.pdf. Accessed 15 December 2024.
42. United Soybean Board. n.d. Rural broadband and the American farmer. Available at: https://api.unitedsoybean.org/uploads/ documents/58546-1-ruralbroadbandwhitepages-final.pdf. Accessed 7 May 2020.
43. Weller, D. L., J. Kovac, D. J. Kent, S. Roof, J. I. Tokman, E. Mudrak, and M. Wiedmann. 2017. *Escherichia coli* transfer from simulated wildlife feces to lettuce during foliar irrigation: A field study in the Northeastern United States. *Food Microbiol.* 68, 24–33.
44. Xu, A., D. M. Pahl., R. L. Buchanan, and S. A. Micallef. 2015. Comparing the microbiological status of pre-and postharvest produce from small organic production. *J. Food Prot.* 78(6), 1072–1080.