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Food Safety of Farmstead Cheese Processors in Pennsylvania: An Initial Needs Assessment

ABSTRACT

There were 97 cheese-related illness outbreaks in the United States between 1998 and 2012, resulting in 2,212 illnesses, 221 hospitalizations, and 10 deaths. Bacteria were responsible for most of the illnesses, with *Salmonella enterica* being the most common bacterium (18.5%), followed by *Campylobacter* spp. (13.6%), and *Listeria monocytogenes* (12.3%); the latter of which was responsible for all of the deaths. Cheeses made by small dairy processors have been involved in several of these outbreaks. However, little is known about this audience's food safety (FS) practices. The goal of this study was to conduct a needs assessment addressing sanitation and FS issues at small cheesemaking establishments in Pennsylvania, using information from dairy inspectors, cheesemakers, and on-site observations. The inspector surveys (n = 6) and observations made during cheesemaking (n = 5) suggest that basic sanitation is a concern. In contrast, the cheesemakers indicated that their self-assessed knowledge, attitude, and behavior were "good" or "very good" in the areas of sanitation (70%) and FS (65%). However, the observations also indicate that these processors may lack basic FS practices and that there are gaps in their FS knowledge, attitudes, and behaviors. Thus, there appears to be a need for FS training, with an emphasis on sanitation, for this underserved audience.

INTRODUCTION

Roughly 1 in 6 Americans get sick every year, making foodborne diseases and outbreaks a major health problem in the U.S. *(30)*. Dairy products cause most of the bacterial-related foodborne illnesses in the country *(26)* and have been responsible for some of the deaths, especially if the milk used is non-pasteurized *(19)*. Between 1998 and 2012, cheese was responsible for 97 outbreaks, causing illness in 2,112 people sick, hospitalizing 221 people, and killing 10 people *(3, 21)*. The causative agent was identified for 81 of the 97 outbreaks,

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with viruses, including norovirus, responsible for 33.3% of these outbreaks. The remaining outbreaks were caused by bacteria: *Salmonella enterica* (18.5%), *Campylobacter* spp. (13.6%), *Listeria monocytogenes* (12.3%), *Staphylococcus aureus* (7.4%), Shiga toxin-producing *Escherichia coli* (4.9%), *Brucella* spp. (3.7%), *Shigella* spp. (2.5%), *Clostridium perfringens* (2.5%), and *Bacillus cereus* (1.2%). Of these, 10 deaths were caused by a single organism, *L. monocytogenes*. In most cases, foodborne outbreaks are associated with improper food handling and can be avoided with simple food safety practices *(34)*.

Over the years, our food system has changed, from a large number of small family farms to a smaller number of large farms that distribute food all across the country. In the past decades, however, consumers have purchased more agricultural products from small farms and local producers, resulting in a boom of the "go local" movement. Additionally, the public's interest in artisan and farmstead cheese has increased, resulting in an uptick in sales and the number of cheesemakers producing those kind of cheeses *(10)*. In the U.S., two-thirds of such cheesemakers opened their business between 2000 and 2011 *(2)*. Nonetheless, only a few studies have focused on food safety issues related to the farmstead cheese industry *(9, 10, 11)*. This industry is characterized by the use of traditional cheesemaking techniques and the frequent use of raw milk, which is legal throughout U.S., especially when such cheeses are aged for at least 60 days *(6)*.

With the proliferation of new artisanal cheesemakers and a lack of food safety training in states like Pennsylvania, the level of knowledge, behavior, and attitude of these artisanal cheesemakers with regard to food safety and sanitation is unknown. By first developing and administering a needs assessment, Extension educators can identify problems and develop educational solutions for this audience *(13)*. Our findings represent a small portion (less than 10%) of the identified farmstead dairy farms in PA *(4)*, but may have applicability for the entire state and other states with small artisan processors.

To our knowledge, there is little, if any, information that addresses the food safety knowledge, behavior, attitudes, or skills of artisan/farmstead cheese processors. Therefore, a comprehensive needs assessment was developed to assess possible gaps in these areas *(20)*. A three-prong approach was used by collecting data from: (1) Pennsylvania Department of Agriculture (PDA) inspectors; (2) cheesemakers; and (3) direct observations of food safety behavior during cheesemaking sessions in processing facilities.

MATERIALS AND METHODS

Recruitment of participants

Participants for the Pennsylvania Department of Agriculture (PDA) inspector survey were recruited through the Director of the Bureau of Food Safety and Laboratory Services. A link for the survey and a password were shared with and distributed by the director to the dairy inspectors via email. There was no direct contact between researchers and the inspectors. Participation was completely voluntary, without incentives, and all responses were kept anonymous.

Multiple sources were used to identify participants for the cheesemaker survey and direct observation visits in Pennsylvania, including announcements during dairy-related Extension events held at the Pennsylvania State University, through PDA's list of cheese-producing permit holders, word of mouth, and on-site visits to farmers' markets. A $10 cash incentive was used to promote participation in the survey. All activities involving human subjects for the needs assessment were reviewed and approved by PSU-Institutional Review Board (IRB #43501).

Inspectors' survey

The inspector online survey was developed and based on PDA's Milk Plant Inspection Checklist. This PDA checklist is organized such that a main item (e.g., floors) must be judged by the inspector as being "In compliance," "Out of compliance," "Not observed," "Not applicable," "Corrected on site," or "Repeat violation." Inspectors were asked which areas/topics were the most common reasons for non-compliance, in addition to how frequently they found items analyzed during inspections to be "out of compliance." This adaptation, with the added question about the most common reason(s) for non-compliance, allowed for a better understanding of common problems encountered by the inspectors.

Two additional questions focused on the inspectors' beliefs about why milk and/or cheese processors might have difficulty staying in compliance with the PDA regulations. Questions also addressed whether inspectors believed training (e.g., Cooperative Extension education) provided by The Pennsylvania State University (Penn State) could help milk and/or cheese processors stay in compliance with current rules and regulations. The final survey was composed of 19 questions. The inspector survey was created with the web tool REDCap™ (Research Electronic Data Capture), which allows for the creation and management of online surveys *(15)*. Approximately 15 minutes were needed for the completion of the survey online. Of the 12 inspectors who were eligible to participate, 6 completed the survey. Results were compiled and answers were transformed into percentages, as needed.

Cheesemakers' survey

Participants were invited to fill out questionnaires during on-site visits to farmers' markets. Ten cheesemakers agreed to take the survey, and five of those agreed to be visited for direct observations.

Questions were developed using methodology described by Witkin and Altschuld *(37)*, to assess cheesemakers' knowledge, attitudes, and behaviors regarding sanitation

and food safety. Penn State faculty, Extension specialists, and three cheesemakers reviewed the survey for grammar, clarity, and time required for completion. The survey consisted of 66 questions (multiple choice, rank, and five-point Likert Scale) with 30 exploratory and demographic, 16 knowledge, 14 behavior, and 6 attitude questions. Average completion time was 20 minutes, and the survey was delivered in a paper-based format. A post-hoc reliability assessment was performed using Cronbach's alpha test on the attitudinal questions of the survey.

A total of 10 surveys were completed, with 8 surveys completed on-site and 2 mailed in to the researchers. Reponses to questions were transferred to a password-protected computer file on a secure computer and without any identifying information.

Direct observations of cheesemakers

Five participants who agreed to be visited on site were contacted beforehand to schedule an appropriate date and time for the visit, the main objective of which was to observe behaviors regarding sanitation and food safety during the cheesemaking process. A quick assessment of the overall cleanliness of the cheesemaking room was carried out using a scale (from one to five, where five is the best condition and one is the worst) to evaluate cleanliness of floor, walls, and ceilings; how cluttered the room was; and how easy it was to clean the facilities properly. Yes/No questions were used to evaluate evidence of pests and if trash was handled properly. Answers for these questions and notes about behavior were taken inconspicuously, using a smartphone app known as Food Safe Surveys *(22, 35, 36)*. Only one researcher carried out the observations; no inter-observer reliability calculation was needed.

Statistical analysis

PDA inspector survey responses, cheesemaker survey responses, and observational data were compiled and analyzed by converting response rates to percentages. Cronbach's alpha tests were used for reliability, where applicable. All mathematical calculations and statistical testing were carried out using Microsoft® Office Excel® 2013 (Microsoft Corp., Redmond, WA).

RESULTS

Inspectors' surveys

Frequent issues were considered when at least half (three out of six) of the inspectors (n = 6) responded that the item was out of compliance, either often (40%–70%), usually (70%–90%), or almost always (more than 90%). The two items most frequently deemed "out of compliance," according to the inspectors who answered the survey, were *Milk Plant Cleanliness* (42% on average) and *Protection from Contamination* (41% on average). Specific issues in those two areas are presented in *Tables 1 and 2*. Inspector responses were based on inspections performed in the past 3–4 years and addressed common reasons why milk and/or cheese processors might have difficulty staying in compliance with regulations *(Table 3)*.

When asked *In addition to PDA inspection, oversight, and outreach, could additional training (Extension education) provided by Penn State help milk and/or cheese processors stay in compliance with current rules and regulations?*, two-thirds of the inspectors (4/6) said yes, one answered "I don't know" (17%; 1/6), and one (17%; 1/6) opted to comment in the question and wrote "Depending upon the owners involved in the operation; some operators are very receptive to training opportunities and information. The training has to

TABLE 1. Frequency of specific issues cited by inspectors as the reason, or one of the reasons, for farmstead cheese operations to be rated as "out of compliance" for the item: Milk Plant Cleanliness — Neat, clean; no evidence of insects or rodents; trash properly handled

Specific issue	Frequency and number of responses (n = 6)
Cluttered	100%; (6/6)
Floor unclean	83%; (5/6)
Walls unclean	83%; (5/6)
Ceiling unclean	67%; (4/6)
Trash not properly handled or removed	33%; (2/6)
Facilities are constructed in a manner which cannot be cleaned properly	17%; (1/6)
Other: *Exteriors of equipment not cleaned adequately*[a]	17%; (1/6)
Evidence of pests	0%; (0/6)

[a]Issue self-reported by a participant in the open-ended option "Other"

TABLE 2. Frequency of specific issues cited as the reason, or one of the reasons, to be rated "out of compliance" for the item: Protection from Contamination — Operations conducted and located so as to preclude contamination of milk, milk products, ingredients, containers, equipment and utensils

Specific issue	Frequency and number of responses (n = 6)
No proper safeguards for the contamination of milk	67%; (4/6)
No proper safeguards for the contamination of milk products	83%; (5/6)
No proper safeguards for the contamination of ingredients	67%; (4/6)
No proper safeguards for the contamination of containers	50%; (3/6)
No proper safeguards for the contamination of equipment	33%; (2/6)
No proper safeguards for the contamination of utensils	33%; (2/6)
Other: *Protection for product, equipment, or packaging needs improvement*[a]	17%; (1/6)

[a]Issue self-reported by the participant in the open-ended option "Other"

TABLE 3. Percentage of Pennsylvania Department of Agriculture inspectors' answers for the question: Based on the results from inspections performed in the past 3–4 years, what are some of the common reasons why milk and/or cheese processors might have difficulty staying in compliance with the regulations? Answers presented in the "Other" section are quoted exactly as stated

Specific issue	Frequency and number of responses (n = 6)
Processors are unfamiliar with the rules and regulations specific to their operation	67%; (4/6)
Processors may not know where to find information regarding the regulations they need to follow	17%; (1/6)
Processors may not have the resources necessary to comply with the regulations	33%; (2/6)
Processors may follow cultural or religious practices, which do not comply with current rules and regulations	17%; (1/6)
I don't know	0%; (0/6)

Other	
a. Just don't see why they should have to.[a]	17%; (1/6)
b. Processors refuse to comply.[a]	17%; (1/6)
c. Processors may become to[sic] hurried to perform tasks properly. Processors may not evaluate the adequacy of their cleaning measures. Inadequate attention to detail. Processors may not have adequate help for their processing operations.[a]	17%; (1/6)

[a]Issue self-reported by the participant in the open-ended option "Other"

be economical to attend, limited in duration, and reasonably close to their operation."

Cheesemakers survey

The cheesemakers (n = 10) described their operation as artisan (60%; 6/10), farmstead (50%; 5/10), or specialty (60%; 6/10). All participants used milk from cows, and one also used sheep milk for cheesemaking. Processors reported making aged (80%; 8/10), fresh (40%; 4/10), soft and/or ripened cheese (10%; 1/10), semi-soft (including washed rind; 40%; 4/10), and mold-ripened (30%; 3/10) cheeses. Raw milk was used for cheesemaking in 70% (7/10) of the

farms, with 89% of the cheese produced on those farms being made from raw milk.

Cheese production per year was well distributed for ranges lower than 100,000 pounds and was presented as follows: (10%; 1/10) < 1,000 lbs; (20%; 2/10) 1,001 – 5,000 lbs; (20%; 2/10) 5,001 – 10,000 lbs; (10%; 1/10) 10,001 – 20,000 lbs; (20%; 2/10) 20,001 – 50,000 lbs; 50,001 – 100,000 lbs (20%; 2/10).

Multiple outlets were used for selling the produced cheese, with direct sales to retailers being the most common (80%; 8/10), and half (50%; 5/10) or more of the participants also using on-farm sales, direct sales to restaurants, and sales at farmers' markets.

Seventy percent (7/10) of the dairies reported making cheese year-round, 20% (2/10) did not make cheese during the winter, while 10% (1/10) make cheese only during winter. Thirty percent (3/10) of the cheesemakers reported that the cheesemaking facilities are unused when not being used for cheesemaking, 30% (3/10) said that the facilities are used for cheese packing or other cheese-related activities, 30% (3/10) said that the facilities are used for other food processing activities, and 10% (1/10) reported using their facilities for either cheese-related or other food processing activities.

Other characteristics of the farms included that 75% of the farms use a milking machine, 60% use well water, 40% make cheese at least two times a week, 50% use either a cheesemaking worksheet or a general Standard Operating Procedure (SOP) for all cheeses, 90% have a hand-washing station in the cheesemaking room, 80% do not have a HACCP or HARPC plan in place, and 70% did not have their final product tested microbiologically.

Sixty percent (6/10) of respondents reported never taking environmental samples for microbiological laboratory testing, 10% (1/10) take samples from the milking stations, 10% (1/10) take samples from the milking receiving room, and 10% (1/10) did not know. Only one cheesemaker (10%) reported taking samples from a variety of sources: milking stations, milk receiving room, cheesemaking room, aging room, packaging room, and storage/shipping room.

Twenty percent (2/10) of the cheesemakers reported being a cheesemaker for less than one year, 10% (2/10) one to three years, 50% (5/10) four to ten years, 10% (1/10) for more than ten years, and 10% (1/10) did not answer this question.

When asked *'How often do you have difficulty putting the food safety knowledge you currently have into practice?'*; 10% (1/10) said always, 60% (6/10) said sometimes, 20% (2/10) said never, and 10% (1/10) did not answer this question.

When asked *'Have you ever changed your cheesemaking practices due to state regulations and inspections?'*; 40% (4/10) said yes, 50% (5/10) said no, and 10% (1/10) said they did not know.

When asked '*Do you believe that the level of bacterial contamination of the milk (raw or pasteurized) that is used to fill the vat to make cheese has a direct impact on the safety of the dairy products?'*, 80% (8/10) said yes and 20% (2/10) said they did not know.

Self-reported data regarding behavior and farm/facilities' characteristics that could impact food safety and sanitation are summarized in *Fig. 1*.

Survey respondents were presented with five cheese-related activities *(milking, manufacture, aging, packing and storage, and selling)* and asked to point out the activity that they believed was most likely to be a source of bacterial contamination in a cheesemaking operation. Results are shown in *Fig. 2a*. Participants were also asked to choose a preferred delivery method for sanitation and food-safety training. The options were *factsheets or other printed materials; training sessions at Penn State (University Park); training sessions locally (< 50 miles from the farm); training sessions on site or at the farm; or training sessions on the Internet.* Results are shown in *Fig. 2b*.

Answers demonstrated that participants were very confident about their own overall knowledge and behavior regarding food safety and sanitation during cheesemaking. At least 60% (6/10) of participants indicated that either their knowledge or behavior about both food safety and sanitation was good or very good. The coefficient of reliability (Cronbach's alpha) for this set of questions was 0.86, above the acceptability threshold of 0.70 *(28)*. Additional results are shown on *Table 4*.

Attitudinal questions regarding food safety aspects, small cheesemaking operations aspects, and regulations and inspections aspects had Cronbach's alpha scores of 0.84, 0.94, and 0.73, respectively. The findings suggest that the majority of participants (90%; 9/10 or more) recognize that their knowledge and behavior has a direct impact on the safety of their dairy products. Most of them (80%; 8/10) are also aware that having separate clothing and shoes might reduce the risk of contamination. Additional results are shown in *Tables 5, 6, and 7*, respectively.

Direct observations of cheesemakers

The data collected about the cleanliness of the cheesemaking rooms are presented in *Table 8*. Only one researcher conducted the observations. The findings suggest major gaps in sanitation and personal hygiene.

For example, during on-site visits, all cheesemakers (n = 5) left the cheesemaking room at least once during the observation. Only one of the cheesemakers washed his/her hands before returning to work and did so every time. This cheesemaker was also the only one who washed his/her hands after touching unclean surfaces during the cheesemaking sessions. For the other four participants, handwashing was scarce, and one participant washed his/her hands only once, at the beginning of the session.

There were other food safety-related issues worth noting. In one cross-contamination episode, a cheesemaker put

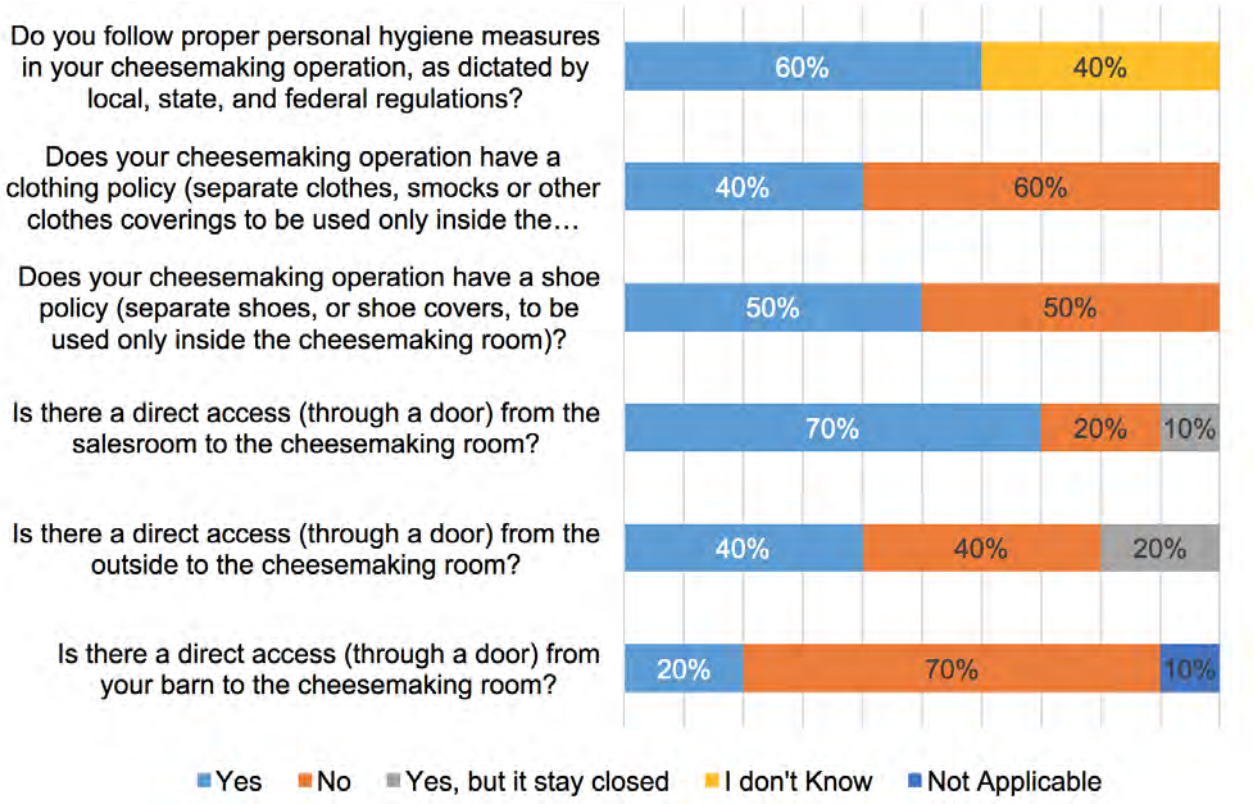

Figure 1. Percentages of responses by farmstead cheesemakers indicating possible food safety issues during a survey conducted in Pennsylvania

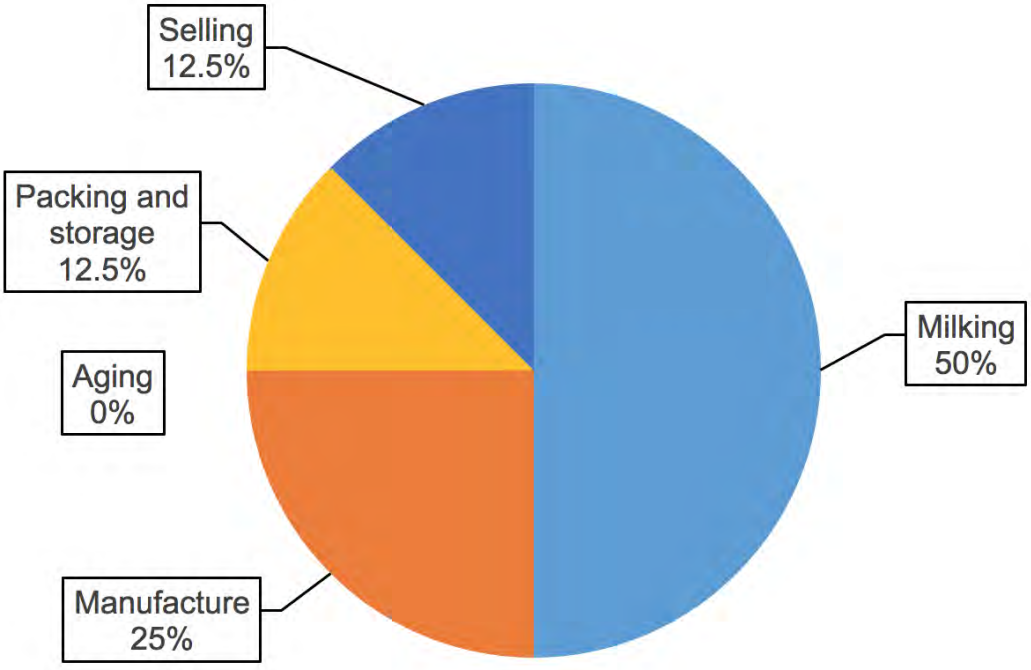

Figure 2a. Farmstead cheesemakers' perceptions of activities likely to be a source of contamination (n = 8) in a Pennsylvania study

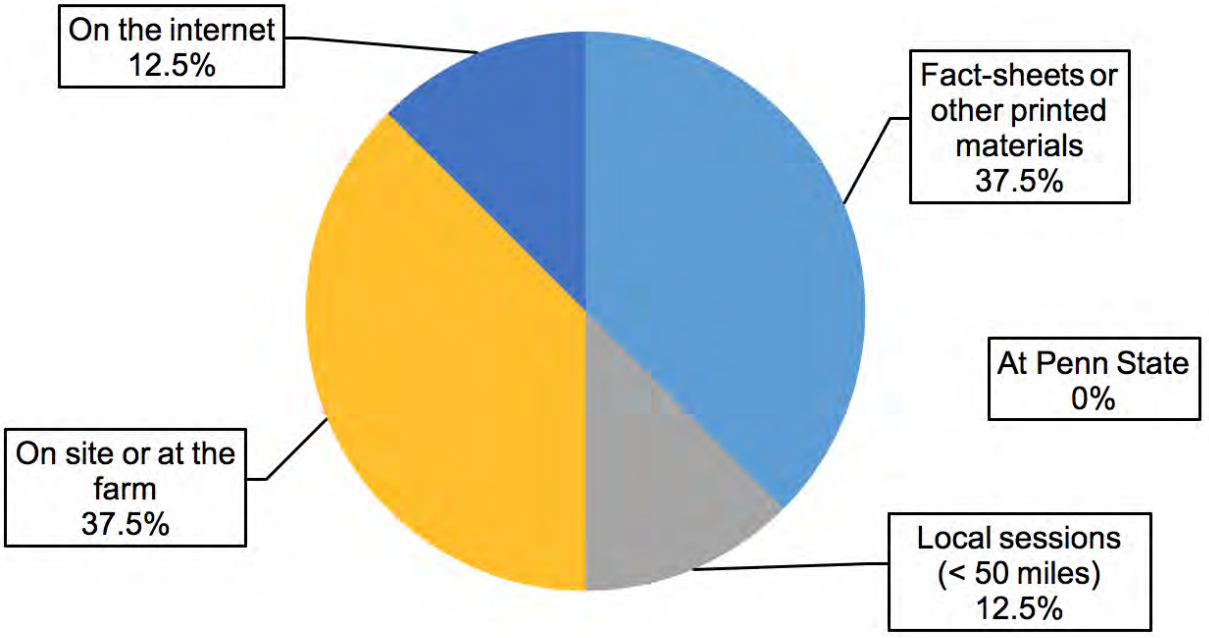

Figure 2b. Farmstead cheesemakers' preferences for training delivery methods (n = 8) in a Pennsylvania study

TABLE 4. Self-reported farmstead cheesemakers' overall knowledge and behavior about food safety and sanitation (n = 10) in a Pennsylvania study

Regarding cheesemaking, how would you rate your knowledge or behavior on the following items?	Very good	Good	Average	Poor	Very Poor
Your level of knowledge about food safety.	50%	10%	40%	0%	0%
Your behavior about food safety.	20%	50%	30%	0%	0%
Your level of knowledge about food sanitation.	50%	20%	30%	0%	0%
Your behavior about food sanitation.	30%	40%	30%	0%	0%

a shovel on the floor, in an upright position with the tip touching the floor and the handle leaning against a wall. When the cheesemaker returned to the processing room, the shovel was picked up and immediately used to stir the milk in the vat. This same farm had an indirect connection between the barn and the cheesemaking room (there was a room between them with a milk tank). Researchers witnessed workers not involved with cheesemaking walking between the barn and the cheesemaking room. Additionally, there was no boot bath or any other measures in practice to avoid or reduce cross-contamination from boot soles. Only two farms had any type of shoe practice; one used a boot bath, and the other had shoes designated to be used exclusively inside the cheesemaking room.

In another instance, a processor used two big pans as vats to make small batches of cheese. After cutting and cooking the curds, the cheesemaker proceeded to mix the curds with his bare arms, although he dipped his hands, forearms and arms in sanitizer before starting to mix. After sanitizing the hands and arms, and before putting his hand inside the pan, he remarked"*… this is the part that the FDA* [Food and Drug Administration] *boys don't like…"*

TABLE 5. Self-reported farmstead cheesemakers' overall knowledge and behavior about food safety and sanitation (n = 10) in a Pennsylvania study

Listed below are statements regarding your perceived knowledge and behavior. Please indicate the degree to which you agree or disagree with the statements. (Food safety aspects)	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My level of knowledge on food safety has a direct impact on the safety of my dairy products.	60%	30%	10%	0%	0%
My behavior about food safety practices has a direct impact on the safety of my dairy products.	60%	40%	0%	0%	0%
There are food safety risks associated with consuming raw milk.	10%	40%	30%	0%	20%
There are food safety risks associated with consuming raw milk cheeses.	10%	40%	10%	20%	20%
Having more information about dairy related foodborne illness may change my behavior regarding food safety practices.	10%	50%	20%	20%	0%
Participating in hands-on demonstrations of proper cheese making practices helps me change my food safety practices.	20%	50%	30%	0%	0%
Having more information about food safety regulations will help me change my behavior regarding food safety practices.	20%	30%	40%	10%	0%
Keeping the milk (raw or pasteurized), that I use to fill the vat to make cheese, refrigerated below 40°F will decrease the chances of having unsafe dairy products.	40%	40%	20%	0%	0%

TABLE 6. Self-reported farmstead cheesemakers' overall knowledge and behavior about food safety and sanitation (n = 10) in a Pennsylvania study

Listed below are statements regarding your perceived knowledge and behavior. Please indicate the degree to which you agree or disagree with the statements. (Small cheesemaking operations aspects)	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My employees or other workers in my facility that are involved in the cheesemaking process, who lack food safety training, have a direct impact on the safety of my dairy products.	30%	40%	20%	0%	0%
Pathogenic bacterial contamination, which could be carried from the milking station to the cheesemaking room, is a food safety concern.	40%	30%	30%	0%	0%
Having separate clothes, smocks or other clothing coverings designated for the cheesemaking room only, will help avoid contamination in my dairy products.	30%	50%	20%	0%	0%
Having separate shoes or shoe coverings designated for the cheesemaking room only, will help avoid contamination in my dairy products.	40%	40%	20%	0%	0%
Having direct access (through a door) from the barn to the cheesemaking room will increase the chances of contamination of my dairy products.	40%	50%	0%	0%	0%
Having direct access (through a door) from the outside to the cheesemaking room will increase the chances of contamination of my dairy products.	20%	50%	20%	10%	0%
Having direct access (through a door) from the salesroom to the cheesemaking room will increase the chances of contamination of my dairy products.	20%	40%	40%	0%	0%

TABLE 7. Self-reported farmstead cheesemakers' overall knowledge and behavior about food safety and sanitation (n = 10) in a Pennsylvania study

Listed below are statements regarding your perceived knowledge and behavior. Please indicate the degree to which you agree or disagree with the statements. (Regulations and inspections aspects)	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
State regulations and inspections of cheesemaking operations ensure that cheesemakers follow correct sanitation procedures.	20%	30%	40%	10%	0%
State regulations and inspections for small cheesemakers like me are necessary to ensure food safety of PA cheese products.	30%	30%	30%	10%	0%
It is important to properly sanitize the cheesemaking room before each use.	60%	0%	10%	20%	0%
I understand the food safety risks that will be minimized if I follow proper sanitation practices in my cheesemaking operation.	20%	60%	20%	0%	0%

TABLE 8. Scores for cleanliness, clutter, design, and pest evidence in farmstead cheese operations, based on direct observations during farm visits (n = 5) in a Pennsylvania study, where five is the best condition and one is the worst

Farm	Overall cleanliness			Clutter	Cleanable design	Pest evidence
	Floors	Walls	Ceiling			
A	1	2	3	1	1	Yes (flies)
B	2	2	3	3	3	Yes (flies)
C	5	5	5	4	4	No
D	4	4	5	3	3	Yes (flies)
E	3	4	4	4	3	No

DISCUSSION

PDA inspectors' answers revealed that plant cleanliness and protection from contamination were two of the four items most frequently identified as out of compliance, as they recalled. Inspectors also pointed out that the most common reason they believe processors have difficulty staying in compliance to regulations is their unfamiliarity with the rules and regulations. The data suggest a lack of acceptable practices regarding basic sanitation and food safety and improper design of facilities and/or organization, possibly due to lack of knowledge about the subject. Lack of knowledge can be remediated with training opportunities *(25, 29)* and might be of great value for this audience. Nonetheless, studies on this clientele are scarce, and this study is potentially the first one to use a multiple approach to gather information about knowledge, behavior, attitudes, and skills of artisanal cheesemakers.

Cheesemakers and PDA inspectors identified time and money constraints as reasons for not following proper sanitation and food safety practices. These are among the most common reasons for non-compliance, as identified by Yapp and Fairman *(38)*, for small and medium-sized food-related enterprises. With that in mind, training opportunities for this clientele must be devised to ensure food safety throughout the dairy industry in Pennsylvania and elsewhere.

Deficiencies in overall cleanliness also were observed during visits, confirming reports by the inspectors. In addition, small cluttered cheesemaking rooms with hard-to-clean designs were frequently observed. A hygienic design with ample room for proper cleaning and storage of equipment is paramount for good sanitation and food safety *(18)*, but it is one of the hardest aspects to improve for this clientele. Similar design deficiencies have been observed in small traditional mountain dairies in Italy and pose a hindrance for possible implementation of GMPs (Good Manufacturing Practices) and HACCP plans *(12)*.

A gap in food safety regularly identified during the visits was the low frequency of handwashing during the cheesemaking session for most of the farms, although handwashing stations were present in all farms visited. Low

frequency in handwashing among food handlers is a known problem *(1, 5, 7, 14, 35, 36)* and multiple efforts have been made to increase adherence *(7, 23, 29, 31, 33)*. Nonetheless, PDA Inspectors did not indicate handwashing and personal cleanliness as major problems in their responses to our survey, possibly because inspectors may not stay during an entire cheesemaking session, or the inspection was done on a non-processing day, underestimating the problem.

Although frequent handwashing was not observed during the visits, 60% (6/10) of cheesemakers reported following proper personal hygiene in the survey. This discrepancy between reported and observed behavior suggests a significant gap in knowledge and/or behavior regarding personal hygiene, specifically with regard to handwashing. This observation is characteristic of an unfelt need *(32)*, which was reiterated by participants reporting their knowledge about food safety (60%; 6/10) and sanitation (70%; 7/10) as being *very good* or *good*. The disagreement between the reported and the observed is of special concern, since these food handlers believe that they follow proper personal hygiene practices.

Handwashing deficiency may be the reason for handles being among the locations with higher microbial and ATP loads, as observed in a preliminary study *(21)*. Handles had been shown to be harborage sites for bacteria and possible sources for cross-contamination *(8, 16)* in food processing facilities. The low frequency of handwashing observed, increased risk of contamination because of the presence of ruminant animals from dairy farms *(17)*, the high counts on handles encountered *(21)*, and possible transfer of bacteria from hands to food contact surfaces *(24, 27)* create a possible high-risk scenario for the small dairy farm. Based on these potential risks, proper personal hygiene should be included as a high-priority item in any training aimed for this audience, with emphasis on handwashing technique and frequency.

Seventy percent (7/10) of cheesemakers reported having difficulty putting their knowledge into practice "always" or at least "some of the time." In addition, most participants either agreed or strongly agreed that their knowledge (90%; 9/10) and behavior (100%; 10/10) regarding food safety have a direct impact on their dairy products. This finding shows that there is a need to help participants apply their knowledge, and that they might be receptive to such training.

Absence of clothing (60%; 6/10) and shoe (50%; 5/10) policies, as well as direct access to the cheesemaking room from a salesroom (70%; 7/10), the outside (40%; 4/10), and the barn (20%; 2/10), indicates that these operations have an increased risk of cross-contamination from clothing and shoes. Kersting et al. *(17)* found that rural homes in Ohio that had ruminant animals were more likely (10 positives out of 26 farms) than rural homes without ruminant animals (3 positives out of 26 farms) to have *L. monocytogenes* on farmers' shoes. Cross-contamination, mainly from shoes and clothes, seems to be an important risk factor for this clientele, and it should be discussed during any training tailored for this audience.

It was concluded that basic sanitation, food safety (e.g. cross-contamination), and personal hygiene (e.g. proper handwashing) concepts should be the focus of a training for the small, family-oriented cheesemaking farm in Pennsylvania. These gaps were identified and reported by PDA inspectors and through on-site observations, yet were different from what cheesemakers reported in their own surveys. The findings also demonstrated that training should be short, preferably done in one session, delivered at the farm, and low cost, because of constraints of time and monetary resources. Therefore, it is proposed that the use of a portable flip chart tool *(29)* could be used to deliver the training anywhere. This kind of delivery tool has been shown to be flexible and efficient *(29)*. Because of the busy schedule of dairy farmers, a training no longer than one hour should be delivered face-to-face on the farm.

LIMITATIONS OF THE STUDY

Because of the survey format used for the PDA inspectors, which asked them to remember the results of past inspections, recall bias might have skewed the results, especially in view of the small number of respondents (n = 6).

For the cheesemakers' survey, the small number of participants (n = 10) was also a limitation. As such, extrapolation of the results to the entire Pennsylvania population, or even the small-scale family oriented dairy farms across the U.S., should be avoided.

The observations conducted on the farms during a cheesemaking day were done by only one researcher and only once. This approach did not allow for inter-observer reliability tests or for test-retest evaluation. However, having participants agree to be visited once and by a known researcher was already difficult; therefore, proposing multiple visits by multiple researches could have reduced the number of participants (n = 5) even further.

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REFERENCES

1. Allwood, P. B., T. Jenkins, C. Paulus, L. Johnson, and C. W. Hedberg. 2004. Hand washing compliance among retail food establishment workers in Minnesota. *J. Food Prot.* 67:2825–2828.
2. American Cheese Society. 2011. ACS Cheesemaker Industry Survey. American Cheese Society. Available at: http://www.cheesesociety.org/wp-content/uploads/2011/02/2011-ACS-Cheesemaker-Survey-Data.pdf. Accessed 16 February 2015.
3. Anonymous. 2012. CDC — Foodborne Outbreak Online Database (FOOD). Available at: http://www.cdc.gov/foodborneoutbreak. Accessed 17 February 2015.
4. Anonymous. 2014. Pennsylvania dairy plant and raw milk directory. Penn State Cooperative Extension. Available at: http://extension.psu.edu/food/dairy. Accessed 22 February 2015.
5. Behnke, C., S. Seo, and K. Miller. 2012. Assessing food safety practices in farmers' markets. *Food Prot. Trends* 32:232–239.
6. Brooks, J. C., B. Martinez, J. Stratton, A. Bianchini, R. Krokstrom, and R. Hutkins. 2012. Survey of raw milk cheeses for microbiological quality and prevalence of foodborne pathogens. *Food Microbiol.* 31:154–158.
7. Chapman, B., T. Eversley, K. Fillion, T. Maclaurin, and D. Powell. 2010. Assessment of food safety practices of food service food handlers (risk assessment data): Testing a communication intervention (evaluation of tools). *J. Food Prot.* 73:1101–1107.
8. Chen, Y., K. M. Jackson, F. P. Chea, and D. W. Schaffner. 2001. Quantification and variability analysis of bacterial cross-contamination rates in common food service tasks. *J. Food Prot.* 64:72–80.
9. D'Amico, D. J., and C. W. Donnelly. 2010. Microbiological quality of raw milk used for small-scale artisan cheese production in Vermont: Effect of farm characteristics and practices. *J. Dairy Sci.* 93:134–147.
10. D'Amico, D. J., and C. W. Donnelly. 2009. Detection, isolation, and incidence of *Listeria* spp. in small-scale artisan cheese processing facilities: A methods comparison. *J. Food Prot.* 72:2499–2507.
11. D'Amico, D. J., E. Groves, and C. W. Donnelly. 2008. Low incidence of foodborne pathogens of concern in raw milk utilized for farmstead cheese production. *J. Food Prot.* 71:1580–1589.
12. Dioguardi, L., and L. Franzetti. 2010. Influence of environmental conditions and building structure on food quality: A survey of hand-crafted dairies in Northern Italy. *Food Control* 21:1187–1193.
13. Garst, B. A., and P. F. McCawley. 2015. Solving problems, ensuring relevance, and facilitating change: the evolution of needs assessment within Cooperative Extension. *J. Hum. Sci. Ext.* 3:26–47.
14. Green, L. R., C. A. Selman, V. Radke, D. Ripley, J. C. Mack, D. W. Reimann, T. Stigger, M. Motsinger, and L. Bushnell. 2006. Food worker hand washing practices: An observation study. *J. Food Prot.* 69:2417–2423.
15. Harris, P. A., R. Taylor, R. Thielke, J. Payne, N. Gonzalez, and J. G. Conde. 2009. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J. Biomed. Inform.* 42:377–381.
16. Kassa, H., B. Harrington, M. Bisesi, and S. Khuder. 2001. Comparisons of microbiological evaluations of selected kitchen areas with visual inspections for preventing potential risk of foodborne outbreaks in food service operations. *J. Food Prot.* 64:509–513.
17. Kersting, A. L., L. C. Medeiros, and J. T. LeJeune. 2010. Differences in *Listeria monocytogenes* contamination of rural Ohio residences with and without livestock. *Foodborne Pathog. Dis.* 7:57–62.
18. Kumar, C. G. G., and S. . K. Anand. 1998. Significance of microbial biofilms in food industry: A review. *Int. J. Food Microbiol.* 42:9–27.
19. Langer, A. J., T. Ayers, J. Grass, M. Lynch, F. J. Angulo, and B. E. Mahon. 2012. Nonpasteurized dairy products, disease outbreaks, and state laws—United States, 1993-2006. *Emerg. Infect. Dis.* 18:385–391.
20. Leagans, J. P. 1964. A concept of needs. *J. Ext.* 2:89–96.
21. Machado, R. A. M. 2016. The effect of an educational intervention on small cheese operations: an exploratory study. The Pennsylvania State University. Available at: https://etda.libraries.psu.edu/catalog/29590. Accessed 29 September 2016.
22. Machado, R. A. M., J. A. Scheinberg, L. F. Pivarnik, and C. N. Cutter. 2015. Use of the smartphone application "Food Safe Surveys" for data collection during direct concealed observations. *Food Prot. Trends* 35:357–364.
23. Medeiros, C. O., S. B. Cavalli, E. Salay, and R. P. C. Proença. 2011. Assessment of the methodological strategies adopted by food safety training programmes for food service workers: A systematic review. *Food Control* 22:1136–1144.
24. Michaels, B., C. Keller, M. Blevins, G. Paoli, T. Ruthman, E. Todd, and C. J. Griffith. 2004. Prevention of food worker transmission of foodborne pathogens: Risk assessment and evaluation of effective hygiene intervention strategies. *Food Serv. Technol.* 4:31–49.
25. Nieto-Montenegro, S., J. L. Brown, and L. F. LaBorde. 2008. Development and assessment of pilot food safety educational materials and training strategies for Hispanic workers in the mushroom industry using the Health Action Model. *Food Control* 19:616–633.
26. Painter, J. A., R. M. Hoekstra, T. Ayers, R. V. Tauxe, C. R. Braden, F. J. Angulo, and P. M. Griffin. 2013. Attribution of foodborne illnesses, hospitalizations, and deaths to food commodities by using outbreak data, United States, 1998–2008. *Emerg. Infect. Dis.* 19:407–415.
27. Pérez-Rodríguez, F., A. Valero, E. Carrasco, R. M. García, and G. Zurera. 2008. Understanding and modelling bacterial transfer to foods: A review. *Trends Food Sci. Technol.* 19:131–144.
28. Radhakrishna, R. B. 2007. Tips for developing and testing questionnaires/instruments. *J. Ext.* 45:1–5.
29. Richard, A. E., J. L. Brown, R. B. Radhakrishna, E. P. Yoder, S. Niet-Montenegro, and C. N. Cutter. 2013. Development and implementation of a "counter-top" training program to increase retention of food safety knowledge, alter behavior, improve attitude and increase skills of Spanish-speaking retail employees. *Food Prot. Trends* 33:10–19.
30. Scallan, E. 2011. Foodborne illness acquired in the United States—major pathogens. *Emerg. Infect. Dis.* 17:7–15.
31. Seaman, P., and A. Eves. 2010. Perceptions of hygiene training amongst food handlers, managers and training providers – A qualitative study. *Food Control* 21:1037–1041.
32. Sheasha, T. 1961. A definition of needs and wants. *Adult Educ. Q.* 12:52–53.
33. Soon, J. M., and R. N. Baines. 2012. Food safety training and evaluation of handwashing intention among fresh produce farm workers. *Food Control* 23:437–448.
34. Todd, E. C. D., J. D. Greig, C. A. Bartleson, and B. S. Michaels. 2007. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 3. Factors contributing to outbreaks and description of outbreak categories. *J. Food Prot.* 70:2199–2217.
35. Vandeputte, E. G., L. F. Pivarnik, J. A. Scheinberg, R. Machado, C. N. Cutter, and I. E. Lofgren. 2015. An assessment of food safety handling practices at farmers' markets in Rhode Island using a smartphone application. *Food Prot. Trends* 35:428–439.
36. Vandeputte, E., L. Pivarnik, J. Scheinberg, R. Machado, C. Cutter, and I. Lofgren. 2014. Use of a phone application to assess food safety practices at farmers' markets (813.6). *FASEB J.* 28:813.6.
37. Witkin, B. R., and J. W. Altschuld. 1995. Planning and conducting needs assessments: A practical guide. Sage Publications, Thousand Oaks, CA.
38. Yapp, C., and R. Fairman. 2006. Factors affecting food safety compliance within small and medium-sized enterprises: Implications for regulatory and enforcement strategies. *Food Control* 17:42–51.