PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 41, No. 1, p. 8–20

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

Nicole L. Richard,[1]* Lori F. Pivarnik,[1]
Christopher Von Achen[2] and Amanda Kinchla[2]

[1]University of Rhode Island, Department of Fisheries, Animal and Veterinary Science, Food Safety Outreach/Research Program, 530 Liberty Lane, West Kingston, RI 02892, USA
[2]University of Massachusetts, Food Science Department, 102 Holdsworth Way, Chenoweth Laboratory, Amherst, MA 01003, USA

Knowledge, Attitudes, and Implementation of Food Safety Practices among Small Food Businesses Operating at Shared-Use Kitchens

ABSTRACT

A survey was designed and conducted to measure knowledge of, attitudes toward, and implementation of food safety practices among food manufacturers operating at shared-use processing facilities in the northeastern United States (Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C.). The survey was distributed online and through the mail. Survey responses were analyzed using SPSS software, and significance was reported at < 0.05. Knowledge item categories included general food safety (6 questions), prerequisite programs (12 questions), and hazard analysis and preventive controls (14 questions). Although respondents (= 47) had an overall correct knowledge score of 82 ± 10, they scored below the 80% mastery threshold for the category of hazard analysis and preventive controls at 77 ± 15. The overall attitude score, based on a 5-point Likert scale, was 4.8 ± 0.3, reflecting a positive attitude toward food safety practices related to food processing. Respondents who received ongoing food safety-related training had higher (< 0.05) self-confidence in conducting food safety-related activities, indicating the importance of ongoing training. Although overall knowledge was satisfactory, the below-mastery score in food safety requirements demonstrated the need for targeted training that would prepare audiences for regulatory compliance.

INTRODUCTION

The development of shared-use processing facilities and incubator kitchens has created opportunities for small and emerging food businesses (SEFBs). However, this audience has been challenged with navigating their way through food safety regulatory compliance *(13)*. Teaching SEFBs how to integrate the culture of food safety into the product development process from the beginning could help these small processors launch local, value-added food products more successfully.

The New England Food Vision predicts that growth in regional food production will strengthen opportunities for economic investment in the local and regional food

*Author for correspondence: Phone: +1 401.874.2977; Fax: +1 401.874.2994; Email: nicolerichard@uri.edu

system *(5)*. Demand for kitchen incubators is evidenced by the steady increase in the number of these facilities. In a 2016 survey of shared-use and incubator kitchens in the United States, more than 200 facilities were identified for assessment *(20)*; in 2020, this number increased to more than 600 facilities nationwide *(3)*. Concurrently, the 2011 Food Safety Modernization Act (FSMA) has promulgated multiple regulations within the food industry *(18)*. The Preventive Controls for Human Food (PCHF) Rule is one of seven areas of focus within FSMA. Although start-up and very small food processors are exempt from the full impact of the regulation, they are subject to modified requirements *(18)*. Small entrepreneurs must still comply with current good manufacturing practices (GMPs), train employees, identify and control the food safety hazards associated with their products, and comply with local and state food safety regulatory requirements. Furthermore, buyer's food safety requirements could include adherence and implementation of PCHF, regardless of processor size, potentially reducing market access for SEFBs.

In a study conducted by Sertkaya et al. *(15)* food industry experts identified the top food safety problems in the U.S. food processing industry and the preventive controls needed to address them. This study indicated that ongoing and targeted training on issues related to food safety (e.g., allergen control, cleaning and sanitizing procedures, improved recordkeeping, and employee training) could address many food safety problems. Other researchers have confirmed the need for innovative training programs for the workforce in all types of food handling businesses and the desire for multiple educational delivery methods, including onsite and on-demand self-paced learning tools that can be accessed as worker schedules permit *(9)*. Training is a significant challenge for smaller food processors because of the costs associated with hiring outside experts or purchasing training materials, which may not be offered in a format that adequately addresses the specific needs and concerns of SEFBs *(2, 9)*. In addition, these processors lack the expertise to develop their own programs or do not fully understand applicable regulations, thereby potentially increasing food safety risk by not understanding the relevance of requirements to the operations of SEFBs. Ongoing education and training are crucial to the successful implementation of any food safety program *(9, 15, 16)*. It is critical that all personnel involved with food processing understand why certain practices are necessary and how to conduct them to build the culture of food safety into business operations. Food safety is a moving target for processors as pathogens evolve and food production practices and processing technologies become more sophisticated *(15)*. Implementing an effective employee training program has been identified as one of five key elements in a comprehensive control strategy for minimizing or preventing food hazards *(9)*; therefore, developing targeted food safety training programs (such as for SEFBs) from product concept before commercialization would be valuable for reducing food safety risks and enhancing market success. Furthermore, providing an initial exposure to the key food safety concepts before more rigorous food safety training (such as PCHF or hazard analysis critical control point [HACCP]) would help to provide a positive learning experience that demonstrates the value of food safety, thus fostering a more comprehensive learning experience that enables a stronger food safety culture.

Little information existed in the literature about the needs of small food processors, and little was specific to the needs of processors in the northeast U.S. region. The need for a strategy to maximize the impact and support for food entrepreneurs in the northeast region resulted in the convening of food safety educators and stakeholders involved with shared-use processing kitchens in 2017 *(13)*. The report from this meeting highlighted a need for a basic food safety primer course that covered food safety considerations from concept to commercialization *(13)*. The food safety program most often cited as serving as the introductory course was geared toward the retail foodservice industry and was aligned with the U.S. Food and Drug Administration (FDA) Food Code *(17)*. There was a recognized need for a curriculum geared toward early-stage food processors that would, with more appropriate content, better prepare food entrepreneurs for the regulatory environment in which they operate *(13)*.

The overall objective of this research was to conduct a needs assessment specific to the food safety educational and training opportunities necessary to support SEFBs (to meet the new FSMA PCHF Rule for processors). The results of this assessment will be used to help develop and implement an appropriate food safety and quality training program customized to SEFBs that would help increase their food safety knowledge and implement an integrated food safety program at the onset of product development.

MATERIALS AND METHODS

Sampling and data collection

Survey development, review, and implementation followed the protocol used by Pivarnik and colleagues for mailed and electronic needs assessments for various target audiences *(10, 11)*. The survey targeted small and emerging food manufacturers operating out of shared-use processing and incubator kitchens. These facilities were targeted because it was the most efficient way to locate small food manufacturers, the target audience for survey distribution. Project directors developed a database from online searches to include contact information for incubator kitchens and shared-use processing facilities in the northeast region (Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C.). Phone calls were made to the facilities to inform them of the project and

upcoming survey, determine their willingness to participate, and confirm their mailing address and the e-mail address of the person who could help facilitate and promote the survey. Surveys were initially administered using an online platform (SurveyMonkey) to reach SEFBs operating at shared-use processing facilities in the targeted states. The online survey was launched 1 October 2018. Contacts in the database (n = 72) were sent an e-mail asking them to forward our survey to their clients. The e-mail contained a letter describing the project and survey and the link to the online survey. In addition, the project advisory board contacts (n = 9) and state contacts (n = 11) affiliated with the Northeast Center to Advance Food Safety were sent an e-mail containing the survey and asked to help distribute it to shared-use facilities on their contact list. The original close date of the survey was November 30, 2018.

The online survey was administered based on one of the strategies outlined by the Dillman total design method *(14)*. This protocol included e-mailing a survey announcement about 2 weeks before survey administration. The survey was e-mailed 2 weeks later. The survey e-mail contained a letter explaining the project and survey. A second reminder e-mail was sent about 2 weeks later. The number of survey responses was lower than desired; therefore, to increase the number of survey responses, the project directors decided to distribute the same survey as a paper version to shared-use kitchen and incubator facilities for dissemination to their members. In January 2019, the paper version of the survey was distributed to the facilities listed in the database. For the paper version of the survey, a box containing 10 to 15 survey packages was mailed to each facility in the database. A total of 72 packages were mailed, with 4 packages returned because of insufficient addresses. Each survey package contained a letter describing the project and survey, along with a self-addressed return envelope. The new close date for the survey for both the online and the paper formats was the end of February 2019. To maximize survey responses for both the online and the paper formats, an incentive ($50 gift card) was offered to 20 respondents via a lottery-type drawing for surveys returned by the February 2019 deadline. Respondents wishing to enter the lottery provided their name and contact information on a form accompanying the paper survey, which was immediately removed from the survey packet upon receipt to protect anonymity. Respondents completing the online survey were redirected from the survey, to protect their anonymity, to a page where they could enter their contact information. Respondents wishing to enter the lottery drawing were consecutively numbered in the order received (i.e., 1, 2, 3, etc.). Using Microsoft Excel (2010), random numbers were generated for 20 respondents to receive the incentive gift card.

Questionnaire

An initial question was asked to screen for those who were food processors and would be required to follow the PCHF Rule; online respondents were directed out of the survey, and paper respondents were instructed that they did not fit the study group and not to continue (e.g., caterer or other retail food operator, seafood, meat or poultry, and juice). The survey included five sections: demographic and background information, food safety practices, knowledge about food safety-related concepts and practices, attitudes toward food safety practices related to food processing, and confidence in conducting food safety practices and training and resource needs.

The survey was designed and implemented following previously published protocols *(1, 11)*. The background section was designed to gather information about the food business, such as the number of years operating, number of employees, type of food products manufactured, and where products are sold. The food safety practices section was designed to determine whether respondents had written procedures for key practices, to learn which practices were being implemented, and to assess their level of confidence in conducting practices as they related to their product or products. The 32 knowledge questions were designed to assess baseline knowledge in three categories: general food safety, prerequisite programs, and hazard analysis and preventive controls (HAPCs). The response for knowledge questions was "agree," "disagree," or "don't know." For statistical assessment, "don't know" reflected a lack of knowledge and was considered an incorrect answer *(10, 11)*. Subject mastery at 80% was used to determine the knowledge base of diverse audiences *(10, 11)*. Attitudes were evaluated toward the importance of (i) food safety practices related to food manufacturing, (ii) producing a safe product, and (iii) perceptions of regulatory compliance. In addition, respondents were asked to rate their confidence conducting specific food safety practices related to processing. These statements were rated on a 5-point Likert scale, with 1 = strongly disagree to 5 = strongly agree. The training and resource needs section was designed to determine the type and format of food safety or other food-related educational and training opportunities this target audience would like to receive, their willingness and ability to invest in food safety-related practices, barriers or challenges encountered during the implementation of food safety practices, and compliance with state or local and federal regulations.

The protocol and questionnaire were approved by the University of Rhode Island Institutional Subjects Review Board. Before implementation, the survey items were reviewed by eight food safety experts for content validity and clarity. Experts were solicited from land grant cooperative extension programs, academic institutions, and the advisory board. The advisory board consisted of nine individuals representing food manufacturers, regulatory agencies, and academic institutions. The questionnaire was revised before distribution based on their recommendations.

Data analysis

Data were analyzed using the statistical program IBM SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk, NY). Analysis of descriptive statistics (e.g., frequencies, percentages, means, and standard deviations), one-way analysis of variance followed by Scheffe's post hoc procedure, correlations, and *t*-tests were performed to determine statistical significance between means. Reliability was determined using Cronbach's alpha measure of internal consistency. For all analyses, the *P*-value for significance was set at $P < 0.05$; $P < 0.1$ (but greater than 0.05) was considered to indicate a trend toward significance *(8)*.

RESULTS AND DISCUSSION

Demographics

The survey targeted food manufacturers operating at shared-use processing facilities that may have to comply with the FDA's PCHF regulation. These facilities were targeted because it was the most efficient way to locate small- and medium-sized food manufacturers. Of the 68 people who began the survey, 17 were caterers or other retail foodservice operations that were not manufacturing food and therefore were disqualified. In addition, some respondents ($n = 4$) indicated that they manufacture juice and cider, seafood, meat and poultry, or pet food only and were not included in the survey, because they comply with commodity-specific food safety regulations, but not the PCHF regulation. Key demographics of survey participants ($n = 47$) are presented in *Table 1*. Almost half (56%) of the respondents were from either Massachusetts or Rhode Island. This may have been because of the strong relationships the project directors have with their state partners. Most businesses responding to the survey had not been operating at the shared-use facility for long, with 63% of the businesses indicating they had been there for 2 years or less. These businesses were very small, with 69% composed of five or fewer employees; 64% were making less than $100,000 in annual sales, and a third were making less than $10,000. Furthermore, 28% did not plan to graduate from the shared-use processing facility and considered it a long-term arrangement. These findings agree with a national study of businesses operating at shared-use processing facilities, which found that 90% of the businesses had five or fewer employees *(20)*. This study also found 46% stayed 1 to 3 years at the shared-use facility, with 29% staying longer *(20)*. A 2020 update found 66% of tenants stayed for 1 to 3 years and another 14% were staying longer than 3 years *(3)*.

The survey found 54% of respondents had prior food industry experience, and most (83%) survey respondents indicated they had received food safety-related training before starting their food business. The top-ranked received training included manager certification (63%), general HACCP (50%), training by experience on the job (51%), allergen management (26%), GMPs (21%), and sanitation (21%) (data not shown). A few (three or fewer) respondents indicated HACCP training (i.e., seafood, meat and poultry, or juice) and PCHF (data not shown). Overall, the high degree of food safety training was unexpected and may be a direct reflection of operating in shared-use facilities, where training could be mandated. In addition, the top-ranked training, manager certification, is aligned with the FDA Food Code and targets the retail food service industry, not food processing.

Facility

Respondents were provided with a definition of a shared-use processing facility and an incubator kitchen to determine which type of facility they operate at. A shared-use processing facility or commercial kitchen was defined as a commercially licensed kitchen in which multiple food businesses can rent blocks of time to produce their food products. An incubator kitchen was defined as a type of shared-use processing facility with a focus on new and early-stage businesses and that provides supportive resources, training, and capacity-building services for food business clients. Kitchen incubators have been shown to improve the long-term survival rates of small businesses compared with facilities that do not provide support services to their clients *(3)*. Of the survey respondents, 47% indicated they operated at an incubator kitchen, 38% indicated they operated at a shared-use processing facility, and 15% indicated other (e.g., copacker, own facility, and share a facility with one business owner; *Table 1*). Most (95%) incubator kitchens required their clients to receive food safety-related education, whereas 70% required ongoing education and 69% offered educational opportunities (data not shown). This was compared with shared-use processing facilities, for which only 56% required training and even fewer required (38%) ongoing education and offered educational opportunities (29%) (data not shown). Of those facilities that required their clients to receive food safety-related education, most required manager certification (71%), whereas some required allergen management (34%), general HACCP (34%), GMPs (17%), and PCHF (14%) (data not shown). Manager certification is a food safety program targeting the foodservice industry and the content aligned with the FDA Food Code. Although it was the most popular choice for providing basic food safety information, it may not be the most appropriate for food manufacturers, whose regulatory requirements are different and often more rigorous. The PCHF training of the Food Safety Preventive Controls Alliance would be more appropriate in content, but this 20-hour course could be overwhelming in both content and scope for smaller and emerging food businesses operating at shared-use processing facilities. Therefore, there is a need for a curriculum that provides food entrepreneurs with a PCHF "light" version that integrates and explains a food safety culture to product developers and manufacturers early in their entrepreneurial process to better help them develop.

TABLE 1. Background information of food processors operating at shared-use processing facilities in the northeast region

Facility background (n = 47)	Frequency	%
State where food business is located (n = 46)		
Massachusetts	14	30
Rhode Island	12	26
Pennsylvania	6	13
Maryland	5	11
New Jersey	3	7
New York	3	7
New Hampshire	2	4
Maine	1	2
No. of employees (n = 47)		
1	13	28
2	6	13
3–5	13	28
6–10	7	15
More than 10	8	17
Primary source of income (n = 47)		
Yes	16	34
No	27	57
Prefer not to answer	4	9
Gross annual sales of food business (n = 47)		
Less than $10,000	15	32
$10,000–$24,999	8	17
$25,000–$49,999	4	9
$50,000–$99,999	3	6
$100,000–$499,999	7	15
$500,000–$999,999	1	2
More than $1,000,000	4	9
Prefer not to answer	5	11
Prior food safety-related experience and training (n = 46)		
Prior food industry work experience	25	54
Prior food safet-related training	38	83
Length of time at current facility (n = 47)		
Less than 1 year	11	23
1–2 years	19	40
3–4 years	7	15
5 years or more	10	21

TABLE 1. Background information of food processors operating at shared-use processing facilities in the northeast region

Facility background (n = 47)	Frequency	%
Length of time until leaving current facility (n = 47)		
Less than 1 year	7	15
1 year	8	17
2–3 years	3	6
More than 3 years	4	9
Don't know	12	26
Not graduating; this is a permanent arrangement	13	28
Type of facility (n = 47)		
Incubator kitchen	22	47
Shared-use processing facility or commercial kitchen	18	38
Other	7	15

Note: The specific number of respondents *(n)* is shown with individual questions to indicate where some respondents didn't answer the question.

Products

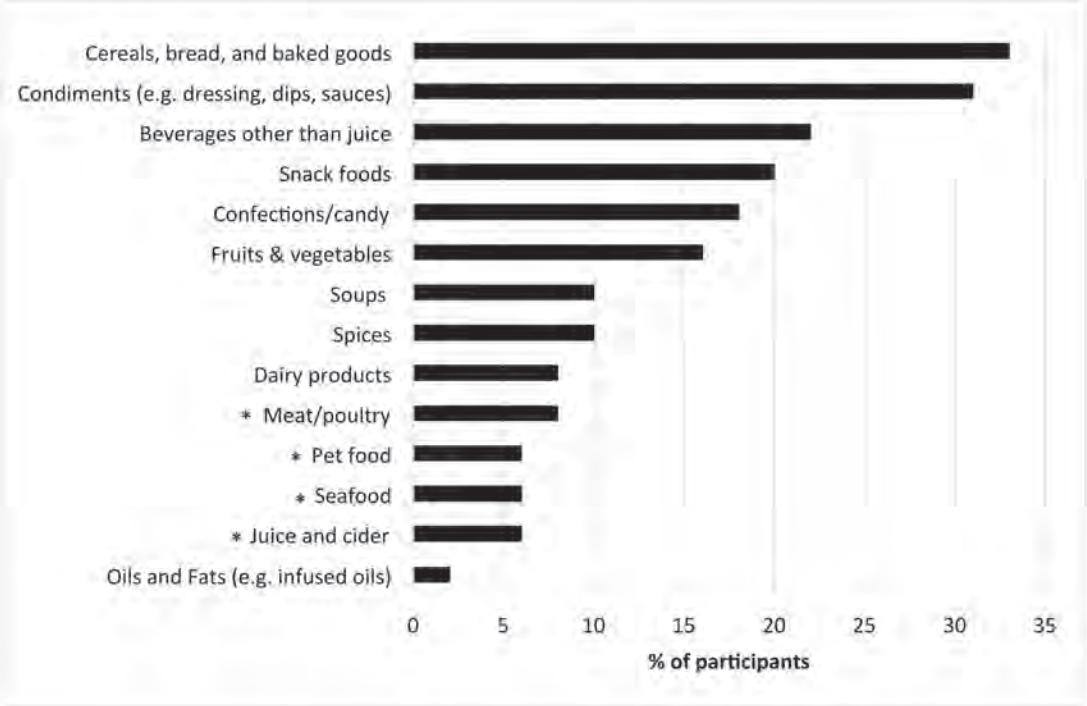
The types of commodities produced by respondents are illustrated in *Figure 1*. The top 5 commodities manufactured were cereals, breads and baked goods, condiments, beverages, and snack foods and confections or candy *(Fig. 1)*. Of the commodities processed, specialty food categories included natural (83%), vegetarian or vegan (83%), gluten free (73%), genetically modified organism free (63%), and organic (64%) (data not shown). Processes used to manufacture food included cooking or baking (47%), canning jams and jellies (26%), canning acidified foods such as salsa and pickles (23%), freezing (23%), and dry mixing (17%) (data not shown), which coincides with the type of top food commodity manufactured (i.e., cereals, breads and baked goods, condiments, etc.; *Fig. 1*). To a lesser extent, but of concern because of the riskier nature of these processes, processes used included canning low-acid foods (13%), fermenting (11%), and using reduced oxygen packaging (9%). A national study also found that ready-to-eat foods (67%) and baked goods (65%) were the most common products made at shared-use kitchens, followed by sauces and spreads (40%), jams and jellies (33%), and spices and rubs (33%) *(3)*.

The top outlets for product distribution included farmer's markets (66%), specialty retail outlets (53%), community events (43%), online (43%), restaurants (38%), and wholesale (38%), as illustrated in *Table 2*. This is similar to what was reported in a national study *(3)*.

Food safety practices

Knowledge

The total knowledge had an alpha reliability score of 0.75, indicating the data were reliable for knowledge measures. *Tables 3 and 4* show the results of the knowledge scores by rank order for items and content categories, respectively. The content questions were designed to reflect general food safety, prerequisite programs, and HAPCs *(Table 4)*. Of the 32 knowledge questions, responses to 9 questions, or 28%, did not meet the 80% correct standard for subject mastery *(10, 11)*. The overall knowledge scores for content categories were 90 ± 16 for general food safety, 84 ± 12 for prerequisite programs, and 77 ± 15 for HAPCs *(Table 4)*. Although the overall knowledge score of 82 ± 10 would indicate overall subject proficiency, knowledge below mastery for HAPCs would indicate a need for training to facilitate specific compliance requirements. Respondents may understand the food safety concepts, but it appears they may not have correct knowledge for implementation. For example, respondents were knowledgeable about the importance of cleaning and sanitizing to minimize food safety risks, but they had low knowledge regarding the proper sequence to do so *(Table 3)*. In addition, the respondents may not fully understand the corrective action options in a food safety plan, because they felt that process parameter deviations could only be corrected by destroying the product. This is an important concept, because the destruction of product is always the last-resort option. Results of this survey agree with perceptions of northeast educators who believed that although food



Note: Processors (N = 4) who indicated they only produce meat/poultry, pet food, seafood and juice and cider were not routed through the survey as they must comply with product specific food safety regulations that are not the Preventive Controls for Human Food rule.

* Other commodities declared, but not covered under the PCHF rule (e.g., seafood, meat/poultry, juice and cider, and pet food)

FIGURE 1. Types of food commodities manufactured by food processor respondents and processed under PCHF (N = 51).

TABLE 2. Channels where food products are sold and distributed (N = 47)

	Frequency	Percent
Farmer's market	31	66
Specialty retail outlet (e.g., bakery)	25	53
Community events (e.g., fairs, festivals)	20	43
Online	20	43
Restaurants	18	38
Wholesale/distributors	18	38
Supermarket/grocery store	17	36
Institutions (e.g., schools, hospitals, correction facilities)	9	19
Other	7	15

Note: Respondents checked all answers that applied.

TABLE 3. Item-level knowledge of food processors regarding food safety practices within content categories, ranked from high to low percentage of correct answers

Knowledge statement within content category	% correct
General food safety items	
Some disease organisms can grow at refrigerated temperatures	100 ± 0
A food safety hazard refers to a contamination in food that has the potential to cause illness or injury to people	98 ± 16
Some disease-causing organisms can survive in a dry environment	97 ± 16
Sources of microbial contamination can come from everywhere (e.g., ingredients, the environment, and people)	95 ± 22
All bacteria in processed food can cause illness	76 ± 43
Chemical food safety hazards account for the most hazards associated with processed foods	67 ± 48
Prerequisite programs	
GMPs are required of all facilities that manufacture, pack, and hold food	97 ± 18
Hand sanitizers are a good substitute for hand washing with soap and water	97 ± 17
Proper hand washing is one of the most important ways to prevent the transfer of harmful microorganisms to food	97 ± 16
Employees with illnesses should be restricted from handling food products, food ingredients, and packaging	97 ± 17
Eating is acceptable in the food processing area as long as the food is in a container with lid	97 ± 17
GMPs require control and exclusion of pests in the process and storage areas	94 ± 24
The grounds outside the food processing facility are not a concern for risk of contaminating the food, because it is outside of the facility	94 ± 23
All utensils and equipment used during food processing must be cleaned and sanitized to minimize food safety risks	94 ± 23
Any chlorine bleach or chlorine-based disinfectant purchased at the grocery store can be used to sanitize food processing areas	82 ± 39
GMPs only address processing plant sanitation	81 ± 40
The proper sequence for a cleaning and sanitation program is to wipe away debris and then sanitize and air dry	54 ± 51
All GMPs implemented must have a record	24 ± 44
Hazard analysis and preventive controls	
Revalidation of a food safety plan is warranted whenever there is a change in equipment, raw materials, or product formulation	100 ± 0
When a hazard analysis is conducted, each processing step must be assessed for chemical, physical, and biological hazards	97 ± 16
Verification includes regular, scheduled activities that ensure the food safety plan is being followed	97 ± 17
Validation process controls are necessary to ensure a food product is safe	94 ± 24
Ready-to-eat foods are fully cooked by the consumer and do not pose a food safety threat	94 ± 23
To understand food safety risks in your product, a written hazard analysis must be conducted	92 ± 28
It is best to use a pencil for monitoring records so that they can be changed if needed	92 ± 28
A processor can use a food safety plan or HACCP plan written by a different company for the same product without conducting its own hazard analysis	88 ± 33
Equipment accuracy and calibration are the same	83 ± 38
A significant hazard is one that occurs in the absence of a control	69 ± 47
Drying helps preserve foods, because disease-causing organisms can't survive	63 ± 49
Sanitizers are necessary to remove food allergens from surfaces	43 ± 50
If pre-established food safety parameters and values (i.e., critical limits) are not met during processing, the product must be destroyed	31 ± 47
A food safety control applied during processing requires a specific minimum and maximum value	13 ± 34

Respondents, n = 29–41. Cronbach's alpha reliability statistic = 0.75.

TABLE 4. Knowledge categories and total knowledge scores[a]

Knowledge category	Mean % correct ± standard deviation	Question range (% correct)	Survey questions below mastery (%)[b]	Total questions
General food safety	90 ± 16	67–100	33	6
Prerequisite programs	84 ± 12	24–97	17	12
Hazard analysis and preventive controls	77 ± 15	12–100	36	14
Total knowledge	82 ± 10	12–100	28	32

[a]Respondents, $n = 29–41$.
[b]Subject mastery = 80%.

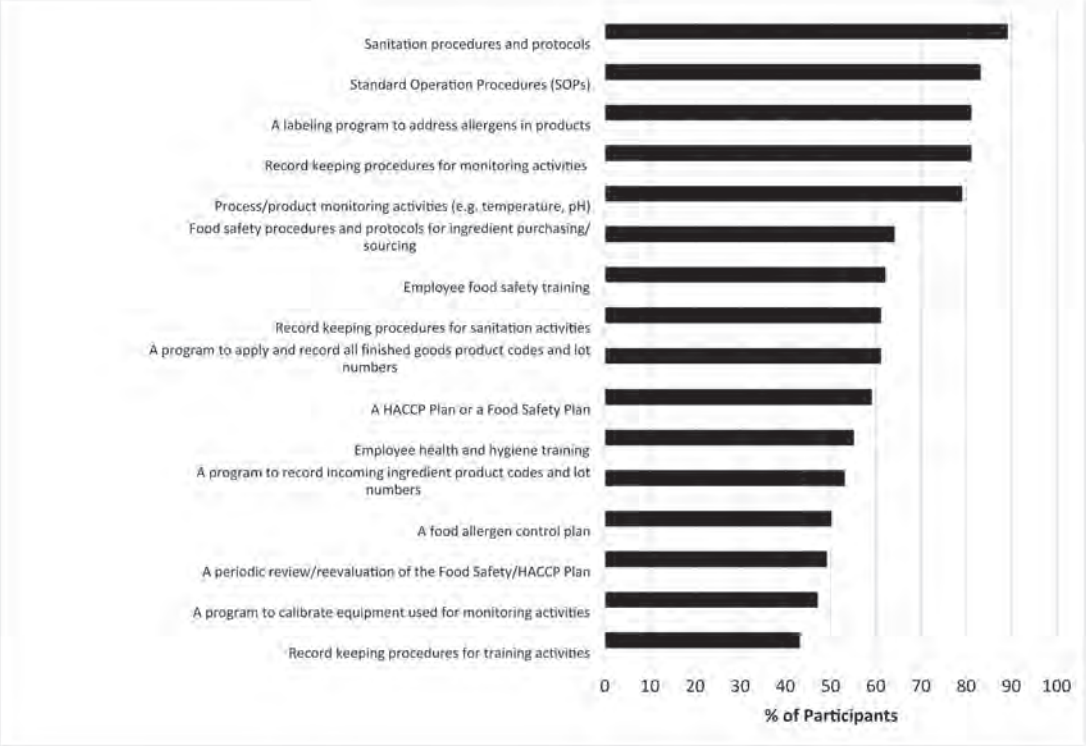


FIGURE 2. Food safety-related practices being implemented by food manufacturers (N = 47).

entrepreneurs are average or somewhat knowledgeable about basic food safety and GMPs, they scored lower for knowledge about risk-based PCHF requirements for writing a food safety plan *(6)*. In addition, a 2020 national investigation *(3)* showed that food entrepreneurs and facility operators need greater support related to product development and recommended a formalized training curriculum, which highlights industry best practices as a means of supporting the shared kitchen industry and to help this industry build capacity. Overall, the proficient knowledge scores may reflect that most respondents were from incubator kitchens (47%) or shared-use facilities (38%) where training was required by 95% and 56%, respectively (data not shown). Therefore, the data may represent an audience that has received food safety education and that is perhaps more engaged in food-safe practices.

Written and implemented practices

Food safety-related practices being implemented versus written are illustrated in *Figures 2 and 3*, respectively.

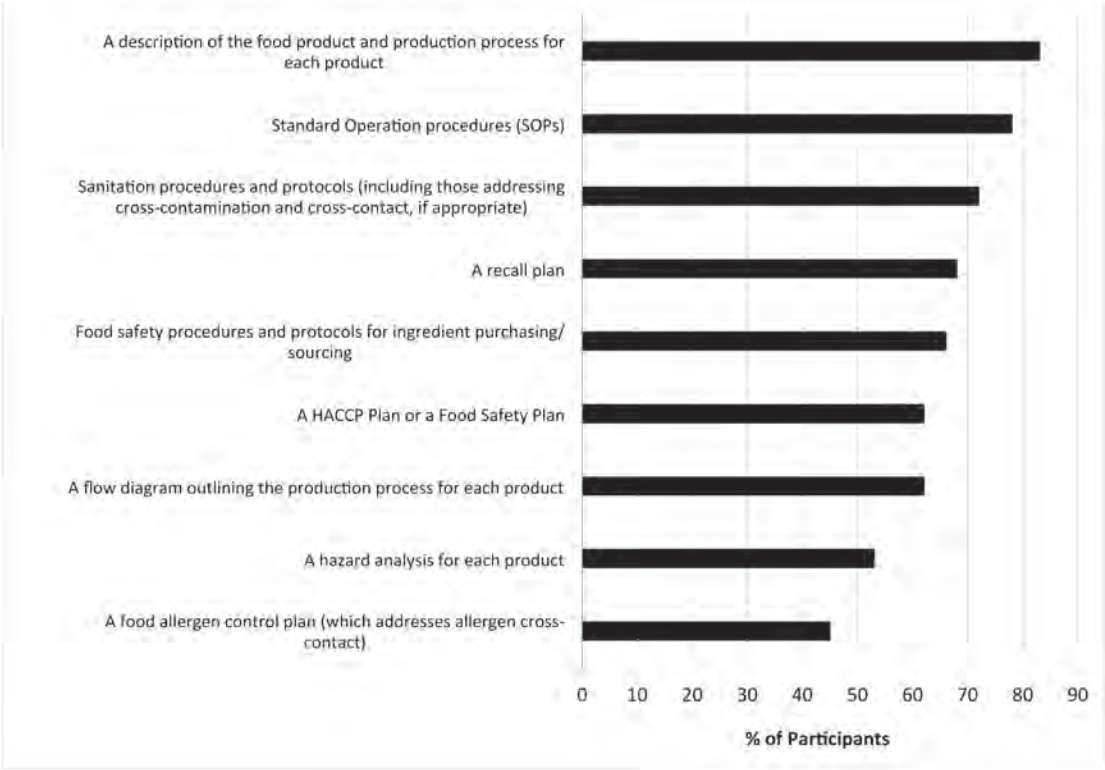


FIGURE 3. Food safety-related practices for which food manufacturer respondents have written procedures (N = 47).

Although most indicated that they are implementing sanitation procedures and protocols (89%), only 61% are keeping sanitation records *(Fig. 2)*. Many SEFBs have implemented process or product monitoring activities (79%) and recordkeeping procedures for those activities (81%). Of concern are the food safety practices that had low levels of implementation: employee food safety training (62%), employee health and hygiene training (55%), and recordkeeping procedures for the training activities (43%). The PCHF Rule has requirements for employee training and the monitoring of those training activities. In addition, only 50% are implementing a food allergen control plan, which could align with the low knowledge regarding allergen control *(Table 3)*, and only 47% have a program to calibrate equipment used for monitoring activities. Our study did not include further investigation to determine whether the SEFB implemented an effective strategy or to confirm that the activities were being implemented correctly. In addition, self-reported food safety-related practices do not always correspond to observed behaviors; self-reported information may more appropriately reflect awareness or indirect knowledge about correct behavior rather than actual behavior *(7, 12)*.

Most survey respondents indicated that they had written procedures for product description (83%), standard operating procedures (78%), sanitation (72%), and ingredient purchasing (66%), as well as a flow diagram (62%), and a HACCP or food safety plan (62%). However, only 53% conducted a hazard analysis for each product *(Fig. 3)*. This would suggest a degree of knowledge and understanding but, overall, a lack in comprehension of the required elements for a preventive control food safety plan. By extension, elements of the food safety plan may not be complete. This indicates a need for clarification regarding the PCHF Rule and how it applies to all food manufacturers.

The top barriers and challenges encountered during implementation of food safety practices were lack of sufficient time (43%), lack of resources to support training (43%), lack of personnel (41%), lack of financial resources for implementation (38%), and lack of financial resources to upgrade facilities and equipment (38%) (data not shown). Small- and medium-sized businesses have different characteristics from large businesses regarding their financial and staffing capabilities *(21)*. Lack of money, time, experience, information, support, interest, and knowledge are often cited as barriers to food safety regulatory compliance *(4, 19, 21)*. It is important to understand the barriers and challenges encountered during implementation of food safety practices to develop strategies to help SEFBs meet regulatory compliance. Targeted and ongoing employee training has been noted as a strategy to address many food safety deficiencies but one that is a challenge, especially for small food businesses *(1, 9,*

15). Although training might increase knowledge, knowledge does not always translate into behavior change *(1, 22)*.

A study looking at the effectiveness of food safety-related training among food handlers found that training should be short in duration and the content should be appropriate in nature *(1)*.

Confidence

Overall, respondents claimed they had reasonably good confidence in conducting food safety-related practices *(Table 5)*. The total confidence score (3.9 ± 0.9) had a Cronbach alpha reliability score of 0.95, indicating the data were reliable for confidence measures. However, although 85% of respondents agreed or strongly agreed they were confident identifying product- and process-related food safety hazards, only 53% conducted a hazard analysis *(Fig. 2)*. Furthermore, only 65% were confident calibrating equipment used for monitoring activities. This lower confidence in calibrating equipment coincides with only 47% or respondents having a program to calibrate equipment used for monitoring activities *(Fig. 2)*. The respondents manufacturing at facilities that offered ongoing food safet-related training had significantly ($P < 0.05$) higher confidence in conducting food safety-related activities. Although there were no differences in knowledge, the self-confidence was higher, indicating the importance of ongoing training.

Attitudes

A total attitude score of 4.8 ± 0.3 (Cronbach alpha reliability score of 0.082) illustrated that respondents had a positive attitude toward food safety practices related to food processing *(Table 6)*. Correlation analysis indicated significant ($P < 0.05$) relationships between attitude and knowledge and between attitude and confidence. The highly positive attitude toward food safety suggests that processors at shared-use processing facilities and incubator kitchens may be more receptive to targeted programming that would improve their understanding and compliance with the PCHF Rule. Although overall knowledge of food safety was proficient, knowledge regarding HAPCs was low, as was the level of implementation of key PCHF requirements (e.g., employee training).

Training and resource needs

More than half (55%) of respondents indicated that they would like educational and training opportunities about food labeling and GMPs; however, only 29% indicated they want PCHF training (data not shown). Even though 74% of respondents said they were aware of the FSMA PCHF regulation (data not shown), they demonstrated low knowledge regarding the PCHF Rule. This may indicate that respondents feel that nothing in the regulation applies to them and that they are unaware that buyers may require full implementation even if they are exempt. This disconnect is supported by a survey of food safety educators who believed that 97% of small to very small processors had no to average awareness of the PCHF requirements *(6)*. Additional food safety content desired by survey respondents included recordkeeping (63%), conducting a hazard analysis and identifying preventive controls (54%), developing a quality control and quality assurance program (54%), and recipe development and product scale-up (54%) (data not shown).

Most would like to receive training in the form of face-to-face workshops (71%); respondents also favored on-demand, self-paced online courses (58%); online interactive tools (58%); and audio presentations (45%) (data not shown). In addition, most would prefer to receive information in the form of newsletters (68%), Web-based handouts (58%), extension publications and fact sheets (53%), and webinars (50%) (data not shown). Finally, although 26% indicated they are willing to pay for training, 62% indicated it depends. A study conducted by Pivarnik et al. *(9)* also found that although in-house food safety-related training was the preferred format for processors, Internet-based training with audio and/or independent learning were desirable alternatives.

CONCLUSION

The survey targeted food manufacturers operating at shared-use processing facilities that may have to comply with the FDA's PCHF regulation. Respondents had overall proficient knowledge and a high number of food safety-related practices self-reported to be written and implemented. However, respondents were not proficient regarding HAPCs. Most respondents had received food safety-related training, had a positive attitude toward the importance of food safety, and had high confidence in conducting food safety practices. Although this survey may have selected for respondents who are more engaged with food safety, it also highlighted that respondents had below-proficient knowledge regarding HAPCs and possibly low awareness of the PCHF regulation.

An educational program that emphasized basic food safety principles regarding food processing, from concept to commercialization, and that aligned with the PCHF regulation would be more useful than existing educational opportunities to SEFBs and shared-use kitchen facilities. A training program that included food safety basics and focused on the elements of the PCHF Rule and its implementation through an interactive approach would better prepare SEFBs for market growth and better position them to understand the regulation with which they must comply. Training opportunities of appropriate content could affect behavior and decision making.

ACKNOWLEDGMENT

This work is supported by the Food Safety Outreach Program (grant 2017-04978, project accession 1014003) from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

TABLE 5. Food manufacturer self-rated confidence in conducting food safety practices related to food processing[a]

Confidence statement	Average score[b] ± standard deviation	% agree to strongly agree[c]
I feel confident identifying product-related food safety hazard(s)	4.2 ± 1.0	85
I feel confident identifying process-related food safety hazard(s)	4.1 ± 1.0	85
I feel confident scaling up my recipe for retail or wholesale production	4.1 ± 1.0	81
I feel confident identifying food safety hazard(s) that can come from the processing environment	4.0 ± 1.1	81
I feel confident establishing corrective actions to take if something does not go as planned	3.9 ± 1.1	76
I feel confident establishing procedures to ensure the control of identified food safety hazard(s)	3.9 ± 0.9	76
I feel confident identifying where to go for food safety and regulatory guidance	3.9 ± 1.1	75
I feel confident identifying all food safety regulations that apply to my food products	3.8 ± 1.2	73
I feel confident establishing monitoring procedures to ensure control of identified food safety hazards	3.8 ± 0.9	70
I feel confident in calibrating equipment used for monitoring activities (e.g., thermometer and pH meter)	3.8 ± 1.2	65
Total confidence score	3.9 ± 0.9	

[a]Respondents, n = 38–39.
[b]Average score was calculated from a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, 5 = strongly agree.
[c]Percentage of respondents who indicated they agree or strongly agree with the statement.
Cronbach's alpha reliability statistic = 0.95.

TABLE 6. Food manufacturer attitudes toward food safety practices related to food processing

Attitude statement	Average score[b] ± standard deviation
Food safety is important to me	5.0 ± 0.2
It is important for my employees to know their role in keeping food safe	4.9 ± 0.3
Proactive approaches to manage food safety risks can minimize foodborne illness outbreaks	4.9 ± 0.3
It is important to identify strategies to manage food safety risks as part of my food business planning	4.9 ± 0.3
It is important to monitor and record food production activities that reflect food safety controls	4.9 ± 0.4
Food safety regulations are important to keep our food supply safe	4.9 ± 0.4
It is important to have written food safety practices and procedures	4.8 ± 0.4
Food safety influences my decision making for my food processing business	4.8 ± 0.4
It is important to invest in food safety from the beginning of the product development process	4.7 ± 0.6
Ongoing food safety training is important to ensure food safety practices are followed	4.7 ± 0.5
Total attitude score	4.8 ± 0.3

[a]Respondents, n = 38–39.
[b]Average score was calculated from a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, 5 = strongly agree.
Cronbach's alpha reliability statistic = 0.82.

REFERENCES

1. Adesokan, H. K., V. O. Akinseye, and G. A. Adesokan. 2015. Food safety training is associated with improved knowledge and behaviors among foodservice establishment workers. *Int. J. Food Sci.* 2015:1–8.
2. Buckley, J. 2015. Food safety regulation and small processing: A case study of interactions between processors and inspectors. *Food Policy* 51:74–82.
3. Econsult Solutions. 2020. U.S. Kitchen Incubators: An industry update. Available at: https://econsultsolutions.com/wp-content/uploads/2020/01/Kitchen-Incubators-2019_1.14.20.pdf. Accessed 29 April 2020.
4. Fielding, L., L. Ellis, D. Clayton, and A. Peters. 2011. An evaluation of process specific information resources, aimed at hazard analysis, in small and medium enterprises in food manufacturing. *Food Control* 22:1171–1177.
5. Food Solutions New England. 2015. http://www.foodsolutionsne.org/new-england-food-vision.
6. Gilbert, A. 2020. NECAFS PCHF awareness and knowledge survey. Available at https://www.uvm.edu/sites/default/files/The-Northeast-Center-to-Advance-Food-Safety/2020AnnualMeeting/NECAFS_needs_assessment_survey_summary.pdf. Accessed 29 April 2020.
7. Hamilton, K. E., J. Umber, A. Hultberg, C. Tong, M. Schermann, F. Diez-Gonzalez, and J. B. Bender. 2015. Validation of Good Agricultural Practices (GAP) on Minnesota vegetable farms. *Foodborne Pathog. Dis.* 12:145–150.
8. Paulin, C., I. E. Lofgren, and L. F. Pivarnik. 2017. An assessment of consumer food safety handling practices of produce at grocery stores in Rhode Island. *Food Prot. Trends* 37(2), 99–106.
9. Pivarnik, L. F., D. Hicks, M. Jahncke, and K. Gall. 2007. Needs assessment survey of sanitation, good manufacturing and hygienic training practices for food processors, wholesalers and warehouse operators. *Food Prot. Trends* 27:400–408.
10. Pivarnik, L. F., M. Patnoad, N. Richard, R. Gable, D. Hirsch, J. Madaus, et al. 2009. Assessment of food safety knowledge of high school and transition teachers of special needs students. *J. Food Sci. Educ.* 8:13–19.
11. Pivarnik, L. F., N. Richard, M. Patnoad, and R. Gable. 2012. Assessment of food safety knowledge and attitudes of managers of residential childcare institutions (RCCI) in the northeast. *Food Prot. Trends* 32:296–308.
12. Redmond, E. C., and C. J. Griffith. 2003. Consumer food handling in the home: A review of food safety studies. *J. Food Prot.* 66:130–161.
13. Richard, N. 2017. Final report: Developing a strategy for optimizing regional support for new and very small local value-added food processors. Final report on planning grant from Northeast Extension Directors (NEED) and Northeastern Regional Association of State Agricultural Experiment Station Directors (NERA). Available at https://www.uvm.edu/extension/necafs/clearinghouse/resources/final-report-developing-strategy-optimizing-regional-support-new-and-very-small-local. Accessed 18 May 2020.
14. Salant, P., and D. Dillman. 1994. How to conduct your own survey. New York: John Wiley and Sons, Inc.
15. Sertkaya, A., A. Berlind, R. Lang, and D. L. Zink. 2006. Top ten food safety problems in the United States food processing industry. *Food Prot. Trends* 26:310–315.
16. Syrko, J., and K. Kaylegian. 2015. Developing a contemporary dairy foods extension program: A training and technical resource needs assessment of Pennsylvania dairy foods processors. *J. Ext.* 53.
17. U.S. Food and Drug Administration. 2017. FDA Food Code. Available at https://www.fda.gov/media/110822/download. Accessed 29 April 2020.
18. U.S. Food and Drug Administration. 2020. FSMA final rule for preventive controls for human food. Available at https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-preventive-controls-human-food. Accessed 29 April 2020.
19. Wilcox, A., B. Ball, and A. Fajumo. 2011. Effective implementation of food safety initiatives: Managers,' food safety coordinators,' and production workers' perspectives. *Food Control* 22:27–33.
20. Wodka, A. 2016. U.S. kitchen incubators: An industry update. Available at: https://econsultsolutions.com/wp-content/uploads/2016/03/U-S-Kitchen-Incubators-An-Industry-Update_Final.compressed.pdf. Accessed 29 April 2020.
21. 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.
22. Young, I., J. Greig, B. J. Wilhelm, and L. A. Waddell. 2019. Effectiveness of food handler training and education interventions: A systematic review and meta-analysis. *J. Food Prot.* 82:1714–1728.