The dissertation of Joshua A. Scheinberg was reviewed and approved* by the following:

Catherine N. Cutter  
Professor of Food Science  
Dissertation Advisor  
Chair of Committee

Rama Radhakrishna  
Professor of Agricultural and Extension Education

Edward G. Dudley  
Associate Professor of Food Science

Luke LaBorde  
Associate Professor of Food Science

Stephanie Doores  
Associate Professor of Food Science

Jonathan Campbell  
Assistant Professor of Animal Science

Robert F. Roberts  
Professor of Food Science  
Head of the Department of Food Science

*Signatures are on file in the Graduate School
Abstract

Since the colonial era, farmers in the U. S. have utilized a constantly changing system of markets to barter, sell, and distribute their farmed goods to the local populace. Today, farmers’ markets have replaced old-world style markets providing more than just local produce. Since the late 1970’s, farmers’ markets in the U. S. have experienced an exponential growth with over 8,200 farmers’ markets operating in the U. S. today. As farmers’ markets have increased in size, scope, and complexity in the kinds of foods sold at these venues, so has the potential food safety risks. Today, farmers’ markets provide thousands of farmers in Pennsylvania and hundreds of thousands in the U. S. an economic opportunity to sell their agricultural products outside of the conventional commercial markets, while also allowing them control during harvesting, processing, packaging, transportation, and final sale of their products, from farm to fork.

While the economic and social impacts of farmers’ markets are no doubt important and positive, previous observational, survey, and microbiological research of farmers’ markets in various regions of North American have revealed that in many cases, farmers’ market vendors can lack important knowledge and experience in food safety practices and behaviors. These studies have also observed vendors performing high-risk retail food safety behaviors, and identified the presence of both hygiene indicator and pathogenic bacteria on select produce, meat, and dairy products. Throughout the past decade, numerous outbreaks and recalls associated with farmers’ market sold food products also have been reported, further highlighting the food safety implications of farmers’ markets. While these incidents have yet to cause mass public illness or capture national media attention, there is a great potential for a single food safety incident to jeopardize the farmers’ market movement, toppling a billion dollar industry,
endangering the livelihoods of hundreds of thousands of farmers’ in the U. S., and causing illnesses and potential deaths of consumers.

To date, several studies have evaluated specific elements of farmers’ market food safety, such as consumer preferences and vendor behaviors, however no one study has used multiple research tools to identify food safety gaps in the same setting. Training programs for farmers’ market vendors also have been developed, however, current available programs may not be focused specifically on food safety, may not be validated scientifically, and content may not be based on actual farmers’ market vendor needs. To date, no current training program has been developed to address the specific and unique needs of Pennsylvanian farmers’ markets and vendors. Therefore the purpose of this study is to assess the unique food safety issues related to farmers’ markets and vendors in Pennsylvania through a comprehensive food safety needs assessment, and based on the results, develop and pilot-test a new customized food safety training program for farmers’ market vendors in Pennsylvania.

The comprehensive food safety assessment was accomplished using five tools: 1) the use of direct concealed observations of farmers’ market vendors in the retail setting; 2) farmers’ market vendor exploratory, knowledge and attitudinal surveys; 3) Pennsylvania Department of Agriculture inspector observational surveys; 4) market manager structured group interviews; and 5) microbiological sampling and analysis of produce, beef, and pork products obtained from Pennsylvania farmers’ markets. An overall comparison and compilation of results from each research tool identified key risk factors and gaps in food safety knowledge, attitudes, and behaviors. Specifically, the microbiological assessment demonstrated that a proportion of select produce and meat obtained from farmers’ markets in Pennsylvania was of questionable microbiological quality, due to the presence of fecal coliforms, E. coli, and Listeria spp. Further
analysis also suggested that *E. coli* isolated from meat and produce had unique phylotypic properties and few isolates exhibited potential pathogenic properties. Results of the observational and survey portions of the assessment revealed that a lack of knowledge and improper behaviors performed by vendors related to hand washing, glove use, thermometer use, packaging use, and cross-contamination, were important risk factors which could be addressed through education and training.

Based on those results, it was determined that food safety training for farmers’ market vendors in Pennsylvania could address food safety knowledge and behavior gaps, potentially leading to safer foods sold at farmers’ markets. Guided by the preferences collected from vendor surveys, the FDA Food Code, and applicable Pennsylvania food safety regulations, a training program consisting of a comprehensive food safety resource guide and associated interactive 3-hour PowerPoint presentation was developed and piloted in several cities across Pennsylvania. Using a pre- and post-test knowledge and attitudinal assessment, it was determined that the piloted training program produced significant increases in knowledge and positive changes in attitudes among vendor participants. The overall results of this study demonstrated that a customized, in-person training program, specifically designed to address gaps identified through a comprehensive needs assessment, is an effective strategy for improving the food safety knowledge and changing the attitudes of farmers’ market vendors in Pennsylvania. Future use of this training program in Pennsylvania and in neighboring states, could serve to further support and sustain the current farmers’ market movement in the U. S., while ensuring public safety and the success of individual vendors.
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Chapter 1

Literature Review
Farmers’ markets and direct-to-consumer marketing in the United States (U. S.)

A Historical Perspective

Since the colonial era, farmers in the U. S. have utilized a constantly changing system of markets to barter, sell, and distribute their farmed goods to the local populace. Population movements from rural to urban areas, in addition to advances in transportation, refrigeration, and other agricultural production technologies, have continued to change the characteristics of the modern food market in the past two centuries (Wann et al., 1948; Brown, 2002a; Brown, 2002b). The oldest known reporting and research conducted on farmers’ markets in the U. S. suggests that the modern concept of direct-to-consumer food marketing, that is, the sale of farmed goods direct from the farmer to the consumer, had become a standard and organized method of commerce in the late 1700s (Wann et al., 1948; Brown, 2002a; Brown, 2002b). These direct-to-consumer markets allowed farmers to sell their farmed products without the use of a broker, distributor, wholesaler, or other supply chain system, which were elements of an evolving and advancing 18th and 19th century U. S. food marketing and distribution system.

According to a United States Department of Agriculture (USDA) report by Wann et al. (1948), now stored in the U. S. National Archives, some of the earliest reported formal agricultural markets operating in the U. S. were located in Albany, New York and Boston, Massachusetts in the 16th century. Wann et al. (1948) also reported that 10 farmers’ markets still operating in 1948 had begun operations just prior to 1800, and 100 farmers’ markets were in operation prior to 1900. Among the oldest markets still operating today, are the Albany Farmers’ Market in New York, started in 1780, and the Easton Farmers’ Market in Pennsylvania, started in 1790 (Wann et al., 1948). Interestingly, other farmers’ markets in the U. S. have claimed to be the oldest continuously operating farmers’ markets in the U. S., however it is likely
that these disputes are the result of constantly changing and non-uniform terminology used to
describe agriculture and food markets in the U. S. (Anonymous, 2015a). Depending on the
author or researcher, reports continue to vary in their definitions of farmers’ markets, regardless
of the efforts to standardize the research, reporting, and data collection.

The first known attempt by economists to formally characterize a farmers’ market was
reported by Wann et al. (1948), in which a farmer’s market was defined simply as “…places
where farmers’ congregated to sell their own products” (Wann et al., 1948; Brown, 2002a).
Although many attempts have been made to formalize the definition and organization of farmers’
markets in the U. S., numerous terms continue to be used by both public and government
organizations to describe farmers’ market-like venues. Terms used in the past and present have
included: terminal markets, public markets, municipal markets, flea markets, tailgate markets,
swap meets, pushcart markets, re-seller markets, roadside or curbside stands, livestock markets
or auctions, wholesale markets, packing sheds, cooperative marketing association markets,
community supported agriculture markets, farm women’s markets, producer only markets, farm
shops, on-farm markets, market fairs, and farm shows (Wann et al., 1948; Brown, 2002a; Brown,
2002b). Presently, the USDA has defined a farmers’ market as, “…a multi-stall market at which
farmer-producers sell agricultural products directly to the general public at a central or fixed
location, particularly fresh fruit and vegetables (but also meat products, dairy products, and/or
grains)” (USDA, 2015a). Regardless of this formal definition, farmers’ market-like venues in
the U. S. continue to utilize variable terminologies to describe themselves, and it is likely that the
research and reporting of farmers’ markets will continue to utilize modified definitions to reflect
the concept of a farmers’ market, as it is known at the present time.
Growth of farmers’ markets in the U.S (1800-2014)

Between 1800 and 1946, historical sources estimate that the number of farmers’ markets in the U.S. had increased from 12 to 455 (Figure 1). Unfortunately, no historical reports have been identified which describe the characteristics or number of farmers’ markets in the U.S. between 1946 and 1970. It is suspected that between 1940 and 1970, farmers’ markets and other direct-to-consumer marketing outlets, may have been in decline due to technological improvements in refrigeration, transportation, packaging, and preservation, which aided in the rise of the chain supermarket (US-GAO, 1980). By 1970, a renewed interest by the consumer to purchase locally sourced food products may have been prompted by a desire to reduce food costs, obtain fresher fruits and vegetables, decrease reliance on imported foods, save energy, and support the dwindling family farm (US-GAO, 1980). As a result of this renewed interest in direct-to-consumer marketing, in 1976 the U.S. Congress passed into the law the Farmer-to-Consumer Direct Marketing Act. This act, which was part of the larger Federal Direct Marketing Program, was designed to provide consumers with cheaper, fresher food, while allowing farmers to receive higher returns on their farmed goods (US-GAO, 1980). The act authorized $3 million for federal grants, which were to be used to “initiate, encourage, develop, or coordinate methods of direct marketing from farmers to consumers” (US-GAO, 1980). In general, funded projects were carried out by Cooperative Extension programs within select states and focused on key areas which included: development of beef marketing, development of audio/visual materials for outreach, direct marketing conferences, improving opportunities for low-income farmers, serving low income consumers, and computerized information and retrieval distribution. Pennsylvania was among 21 states with funded projects, and focused efforts on
direct marketing in Philadelphia to provide low-income farmers with direct marketing opportunities to serve city residents, including low-income consumers (US-GAO, 1980).

Today, Philadelphia is home to a thriving farmers’ market community, with 81 farmers’ markets located within city limits or in close-by commuter suburbs in Pennsylvania and southern New Jersey (Salisbury, 2015). Nearly a decade following the Farmer-to-Consumer Direct Marketing Act of 1976, the number of farmers’ markets increased by approximately 180% to 1,697 in 1986, demonstrating the success of the Act and supported programs (Figure 1). Furthermore, a steady increase in the number of farmers’ markets has occurred in the U.S from 1976 to the present day, resulting in an increase of 12 times the number of farmers’ markets existing in 1976 to 8,268 farmers’ markets in operation in 2014. Since 1976, the passing of other federal initiatives also helped sustain the growth in farmers’ markets through funding support, as well as focusing efforts on targeted consumer groups and struggling city centers (Martinez et al., 2010). These programs have included: the Community Food Project Grants Program, the Women, Infants, and Children (WIC) Farmers’ Market Nutritional Program, Senior Farmers’ Market Nutrition Program, Federal State Marketing Improvement Program, National Farmers’ Market Promotion Program, Specialty Crop Block Grant Program, and the Community Facilities Program (Martinez et al., 2010).

Economics and products sold at farmers’ markets

The success and continued growth of farmers’ markets and other direct marketing outlets in the decades following the Farmer-to-Consumer Direct Marketing Act of 1976 not only demonstrated the increase in number of farmers’ markets across the U. S., but also in the value of agricultural products sold and the number of farms participating in direct-to-consumer marketing. In 1992, 86,432 U. S. farms generated direct-to-consumer sales of ~$404 million
Figure 1: Number of farmers’ markets in the U. S. (1800-2014).
Note: Reported number of farmers’ markets in each year was determined using multiple sources: Brown, 2002b; Martinez et al., 2010; USDA, 2011a; USDA, 2011b; USDA, 2012; USDA, 2013; USDA, 2014a; X-axis is not to scale, data is not available for each year).
(Hughes et al., 2015). A decade later, in 2002, 116,733 farms generated ~$812 million, and in 2007, 136,817 farms produced ~$1.2 billion in direct-to-consumer sales (USDA, 2009; USDA, 2014b; Hughes et al., 2015). The most recent 2012 U. S. Census of Agriculture has reported that in 2012, 144,530 farms participated in direct-to-consumer marketing generating ~$1.3 billion in sales. Interestingly, direct-to-consumer sales still account for less than 1% of total agricultural sales in the U. S. (USDA, 2009; USDA, 2014b), yet more farms continue to choose to participate in direct-to-consumer sales each year.

By looking locally at each state and county in the U. S., the impact of farmers’ markets can be more clearly seen. For instance, in New York, which contains the second largest number of farmers’ markets in the U. S., 18% of farms in New York participated in direct-to-consumer marketing, generating more than ~$100 million in sales in 2012 (USDA, 2014b). On average, New York farms participating in direct-to-consumer sales in 2012 generated $15,000/individual farm (USDA, 2014b). In California, 11% of California farms participated in direct-to-consumer sales generating ~$169 million, which equates to $19,000/individual farm (USDA, 2014b). Alternatively, in a state less associated with agriculture such as Alaska, over 32% of Alaskan farms participated in direct-to-consumer marketing, but generated only ~$2.2 million in total direct-to-consumer sales. These census data suggest that although farmers’ markets and other direct-to-consumer marketing outlets may appear to have a small impact on U. S. agriculture at a national level, their impacts may be much more evident and important at the state and local levels.

In 2014, the USDA reported the following top 10 states with farmers’ markets in the U. S.: California (764 markets), New York (638 markets), Michigan (339 markets), Ohio (311 markets), Illinois (309 markets), Massachusetts (306 markets), Pennsylvania (297 markets),
Wisconsin (295 markets), Virginia (249 markets), and Missouri (245 markets) (USDA, 2014a). Further examination of the number of farmers’ markets per county in these top 10 states would show that in California, there are ~13 farmers’ markets/county, in New York ~10/county, and in Pennsylvania ~4/county in 2014. As a comparison, the national count of grocery stores in the U. S. in 2014 was estimated to be 37,716, producing on average ~12 grocery stores/county among the 3,142 counties in the U.S (Anonymous 2015b). Considering that each farmers’ market can host large numbers of individual vendors, this basic census analysis also suggests that farmers’ markets in the U. S. may be a significant source of food products for millions of U. S. citizens outside of traditional grocery stores.

One of the most defining features of farmers’ markets is the large variability in the types of products sold. As farmers’ markets continue to increase in number across the U. S. so has the number of products that are typically sold by individual vendors. In fact, the recently completed USDA Agricultural Marketing Service (AMS), National Farmers’ Market Directory, accessible on the internet, lists 28 categories of food products which vendors have reported selling at their respective markets. Some of the more unique categories include: tofu, wild harvested mushrooms, pet food, prepared foods, wine, beer, and hard cider, seafood, and coffee (USDA, 2015b). In 2005, a comprehensive USDA Market Manager survey was performed, and reported that 91.8% of farmers’ markets were selling fresh produce, while meat or poultry were sold at 45% of farmers’ markets, prepared foods at 38%, and fish or seafood were sold at 16% of farmers’ markets in the U. S. (Ragland and Tropp, 2006). Based on the data provided by Ragland and Tropp, (2006), in 2005 fresh produce was sold at an estimated 3,757 farmers’ markets, meat or poultry was sold at 1,841 farmers’ markets, prepared foods were sold at 1,555 farmers’ markets, and 654 farmers’ markets were selling fish or seafood (Ragland and Tropp,
In contrast, the number of farmers’ markets selling the same items in 2015 has changed dramatically. Currently, the USDA National Farmers’ Market Directory reports that 3,101 or 36% of farmers’ markets in the U. S. sell prepared foods, 5,061 or 60% sell meat or poultry, and 1,254 or 15% sell fish or seafood. This simple comparison demonstrates that as farmers’ markets have increased in number over the past decade, so have the number of vendors selling the more unique categories of food products. These data also demonstrate that although fresh produce remains the dominant product sold, products such as meat or poultry and prepared foods are much more common place and present at farmers’ markets then they ever have been in history (USDA, 2015c).

Food safety implications of farmers’ markets

Exploring the kinds of food products sold at farmers’ markets is an important step in assessing food safety implications associated with farmers’ markets. In the past decade, reports have shown that more foods requiring specialized processing and handling are being sold at farmers’ markets across the U. S. (USDA, 2015c; Ragland and Tropp, 2006). In particular, foods which the Food and Drug Administration (FDA) refers to as “Time/Temperature Control for Safety” or TCS foods, previously referred to as potentially hazardous foods, are now commonly sold at farmers’ markets (FDA, 2013; USDA, 2015c). In general terms, TCS foods are foods which require cold holding or hot holding at specified temperatures following their normal preparation or processing to ensure their safety and prevent the growth of pathogenic microorganisms on those foods (FDA, 2013). Common TCS foods found at farmers’ markets can include: raw meat (beef, pork, goat, lamb, venison), raw poultry (chicken, turkey, other fowl), seafood (fish, shellfish, other seafood), raw and pasteurized dairy products (milk, cheese, yogurt, butter, cream, and others), deli meats, washed shell eggs, sliced fruit and vegetables.
(leafy greens, tomatoes, cantaloupe, melon), raw sprouts, cooked vegetable foods (potatoes, rice, and others), and prepared foods containing TCS food ingredients (FDA, 2013; USDA, 2015c).

Foods which are categorized as ready-to-eat (RTE), also have become commonplace at farmers’ markets in the U. S. (USDA 2015c). The term RTE refers to foods which are edible without additional preparation in order to achieve food safety (FDA, 2013). RTE foods found at farmers’ markets in the U. S. can include: baked goods (breads, pies, cookies, and others), fresh or dried herbs, honey, maple syrup, nuts, mushrooms, fresh fruits and vegetables which have been washed, canned or preserved as well as jams, and jellies, sauces, coffee, tea, juices, and various cooked food items which are served at the point of sale (FDA, 2013; USDA, 2015c). Due to the high volume of TCS and RTE foods sold at farmers’ markets in the U. S. it is questionable whether farmers’ market vendors who prepare, process, transport, store, and sell both TCS and RTE foods have the necessary knowledge and experience in food safety and food processing to ensure the safety of those higher-risk products.

Fortunately, several studies have begun to explore food safety risks at farmers’ markets and identify high-risk food safety factors unique to farmers’ markets and farmers’ market vendors. In 2004, researchers in Ontario, Canada performed observations of 17 cheese vendors at farmers’ markets and reported numerous high-risk food safety behaviors (Teng et al., 2004). In their study, Teng et al. (2004) reported that 47% of observed cheese vendors were not properly refrigerating cheese, 88% of cheese vendors did not wash their hands before or after handling cheese, and 24% stored cheese at the farmers’ market next to raw foods such as meat. In a similar study, Mcintyre et al. (2014) surveyed 107 farmers’ market vendors in British Columbia, Canada on food safety related behaviors and knowledge. Among the major knowledge gaps revealed, 34% of farmers’ market vendors were unable to identify potentially
hazardous foods among a list of common foods, 29% were unable to identify proper methods of reducing the temperature of potentially hazardous foods, and 29% were unable to determine whether jams, jellies, and marmalades required pH and water activity testing for safety (Mcintyre et al., 2014). In an alternative study, Harrison et al., 2013 explored on-farm food safety practices of farmers growing produce sold at farmers’ markets in Georgia, Virginia, and South Carolina. Among the 226 farmers and 45 market managers surveyed, Harrison et al. 2013 reported that approximately 36% of surveyed farmers were using manure which was not properly composted to grow produce for sale, potentially increasing the risk of pathogen contamination associated with un-composted manure. Harrison et al. (2013) also reported that 50% of surveyed farmers harvested crops with bare hands, yet only 66% had hand washing facilities and bathrooms available near their fields or packing areas, potentially increasing the spread of foodborne pathogens such as norovirus. In addition, only 39% of farmers surveyed indicated that surfaces which came into contact with harvested fruits and vegetables destined for sale were sanitized (Harrison et al., 2013).

Surveillance, outbreaks and recalls

In addition to survey and observational studies of farmers and vendors, previous research also has attempted to measure the prevalence of specific pathogens or indicator microorganisms on food products sold at farmers’ markets. In 2009, Canadian researchers collected over 600 samples of fresh produce from 36 farmers’ markets in Alberta, Canada to determine the prevalence of hygiene indicator bacteria, *E. coli*, and parasites in sampled produce (Bohaychuk et al., 2009). Among sampled produce, Bohaychuk et al. (2009) reported 18% of lettuce (n=128), 27% of spinach (n=59), and 5% of green onion (n=129) samples were positive for *E. coli*, with an additional spinach sample positive for *Cryptosporidium*. A comparative study on
farmers’ market and supermarket raw whole chicken by Scheinberg et al. (2012), identified that 28% and 90% of whole chicken purchased from farmers’ markets (n=100) were positive for *Salmonella* spp. and *Campylobacter* spp., respectively, compared to 8% and 52% of poultry purchased at supermarkets (n=100) positive for the same pathogens. Most recently, Pan et al. (2015) assessed the prevalence of fecal coliforms, *E. coli*, and *Salmonella* present on fresh produce unique to the Asian cuisine from 21 Asian farmers’ market vendors in Northern California. Their results revealed that among 242 vegetable samples consisting of basil (n=23), okra (n=43), radlong beans (n=72), squash (n=89), and cilantro (n=15), fecal coliforms were detected in 100% of samples, 20% of samples were positive for *E. coli*, and 7% of samples were positive for *Salmonella* serovars Newport, Enteritidis, Agona, and Worthington (Pan et al., 2015).

In another related study occurring in the Western U. S. Levy et al. (2014) assessed the prevalence of generic *E. coli* and *Salmonella* in fresh herbs (cilantro, basil, parsley) sold at farmers’ markets in Los Angeles, CA and Seattle, WA. Among the 133 fresh herb samples obtained from 13 farmers’ markets, one sample of parsley was found to be positive for *Salmonella* while 24% of the fresh herb samples were positive for *E. coli*, with basil showing the highest prevalence (27%) of *E. coli* among the three herb types (Levy et al., 2014). In a most recent Canadian study by Wood et al. (2015), various types of lettuce were sampled from farmers’ markets in Vancouver, British Columbia to assess the prevalence of *E. coli* on sampled lettuce. Their results revealed 13% of sampled lettuce (n=68) were positive for *E. coli*, with some samples containing *E. coli* counts as high as 3.0 log CFU/g (Wood et al., 2015). Interestingly, Wood et al. (2015) also reported that 36% of *E. coli* isolates were resistant to nalidixic acid, 24% to ampicillin, 30% to kanamycin, and 58% to amikacin. Likewise, Leang
and Meschke, (2013) sampled lettuce and tomatoes from 5 Seattle farmers’ markets, and reported that 62% of lettuce (n=39) and 6% of tomato (n=63) samples were positive for E. coli, with concentrations ranging from 1 to 756 CFU/100ml.

The combined body of research which has investigated farmers’ markets to date, using surveys, observational studies, and microbiological sampling, continue to demonstrate that serious gaps in food safety knowledge and behaviors of farmers and farmers’ market vendors in North America exist which can translate into significant microbiological hazards being present in food products sold at farmer’s markets. Unfortunately, the kinds of microbiological hazards identified to be present on foods sampled from farmers’ markets in previous studies, have caused several documented foodborne outbreaks associated with foods sold at North American farmers’ markets. Unbeknownst to many, outbreaks from foods purchased at farmers’ markets are more common than one might expect.

In 2008, 18 people fell ill to Campylobacter spp. infections after consuming contaminated raw bagged peas sold at five south-central Alaskan farmers’ markets (Gardner et al., 2011). In 2010, guacamole, salsa, and/or tamales sold at several Iowa farmers’ markets were the source of a Salmonella outbreak which sickened 25 people (Anonymous, 2010a). Strawberries sold at roadside stands and several farmers’ markets in Oregon made headlines as the source of an E. coli O157:H7 outbreak which sickened 16 people and caused one death in 2011 (Goetz, 2011). Contaminated raw milk, sold at a Pennsylvanian farm and other retail operations in the state, was the source of a large Campylobacter outbreak, sickening 38 people in 2012 (Anonymous, 2012a). In January 2014, the CDC confirmed 14 cases of Salmonella that were attributed to “cashew cheese” which was sold in several farmers’ markets in California’s Sacramento County, as well as other retail markets in California, Nevada, and Wyoming.
(Anonymous, 2013a). In addition to these reported outbreaks, the California Department of Food and Agriculture recalled raw cream sold at several farmers markets and retail outlets in the Fresno, CA area in 2007 due to *Listeria monocytogenes* contamination (Anonymous, 2007). Similarly in 2012, cheese tested positive for *L. monocytogenes* after being sampled by the Washington State Department of Agriculture, resulting in recalls from farmers’ markets in three counties (Anonymous 2012b).

In February, 2014, a farmers’ market vendor was also the first to be convicted under Michigan’s Food Law after he pled guilty to willful misbranding and adulteration of food products (Holton, 2014). This conviction was the result of an *E. coli* O157:H7 outbreak associated with the vendor’s apple cider sold at a Michigan farmers’ market, which sickened four, including two children. After being cited by the Michigan Department of Agriculture for being an unlicensed cider processor and producing cider under unsafe production standards, the vendor continued to produce and sell his cider until he was charged with criminal negligence for producing food that caused illness and injury to unsuspecting consumers (Holton, 2014). Most recently, a food truck, named Los Chilangos which served Mexican food at a Seattle farmers’ market was reported to be responsible for an *E. coli* O157:H7 outbreak, sickening 9, including a 4 year old girl, who was hospitalized with kidney failure following consumption of carnitas (Siegner, 2015). Public health officials reported finding cross-contamination potential and overall conditions of the food truck unsatisfactory, leading to the suspension of Los Chilangos operations (Siegner, 2015). Although surprising, these instances of foodborne illness, recalls, and criminal negligence are a clear indication that the severity of food safety risks associated with farmers’ markets and direct-to-consumer marketing have not been fully grasped.
**Regulations and laws**

Historically, farmers selling food products at farmers’ markets in most U. S. states were exempt from the regulations and policies of food safety and sanitation which applied to retail-type food establishments. In the past decade however, public health regulations specifically addressing farmers’ markets have continued to evolve at the state and local government levels. For instance, between 2010 and 2011, Arizona, Florida, New Jersey, South Dakota, Washington, Pennsylvania, Maryland, and Oklahoma all passed specific state legislation addressing farmers’ markets in the areas of food safety, food fraud, licensing, and establishing rules for the kinds of foods allowed to be produced for sale at farmers’ markets (O’Brien, 2011). Most recently, California passed the Assembly Bill No. 1871, effective in 2015, which specifically created new laws and regulations pertaining to direct-to-consumer marketing, the requirement for vendors to obtain a “certified farmers’ market certificate”, and the requirement for farmers’ market vendor inspections by state or local health officials (Anonymous, 2014).

Among states with current regulations and laws for farmers’ markets, Pennsylvania has been the most proactive in introducing regulations addressing food safety of farmers’ markets and actively inspecting farmers’ market vendors around the state. Much of the emphasis on farmers’ market food safety in Pennsylvania was the result of Pennsylvania Act 106, implemented in 2011, which established specific licensing requirements for vendors, detailed policies on the types of foods allowed for sale and the conditions in which they could be processed, labeling requirements, and additional sanitation requirements at individual markets and in facilities used to prepare and process foods for sale at farmers’ markets (Anonymous, 2011a). Since many of these new laws and regulations have been passed recently and begun to be enforced, it is unknown how they will affect the current growth and popularity of farmers’
markets, and if increased oversight will reveal a greater degree of food safety risks already identified by current research.

**Needs Assessments**

**Methods and background**

The basic concept of a needs assessment is assumed to have begun to gain traction in the scientific community following the works of Abraham Maslow, who popularized the concept of human needs in psychology in the 1950s (Altschuld and Watkins, 2014). A decade later the Elementary and Secondary Education Act of 1965 generated renewed interest in the use of exploring needs, by specifying the requirements to identify needs for educational programs and projects in the U. S. (Altschuld and Watkins, 2014). Throughout the 1970s and leading into the 1990s, three leading social scientists had pioneered two separate models of needs assessments and planning which are considered the standard models to be used today (Altschuld and Watkins, 2014). In 1995, the works of Witkin and Altschuld, outlined a three phase approach to planning and conducting needs assessments, while concurrently Kaufman developed the Organization Elements Model (OEM). Today, both models are considered standard methodologies for conducting needs assessments (Altschuld and WatKing, 2014). Interestingly, outside of the child educational program development field, major early users of needs assessments were scientists and educators involved in Cooperative Extension education (Leagens, 1964). In the Extension Program Development Model, described by Leagens, (1964), the needs assessment was the first step in the model, and is still considered a critical step required to develop effective Extension programming today (Garst and McCawley, 2015; Leagens, 1964).

Regardless of the model used, a needs assessment refers to the methods, efforts, and activities involved in or used for identifying needs (Royse et al., 2009; Garst and McCawley,
A need can be defined as a measurable gap between two conditions, or in other words, the difference between “what is” and “what should be” (Kaufman, 1988; Altschuld and Watkins, 2014; Garst and McCawley, 2015). Needs assessments can also provide insight into what already has been done and what gaps in learning remain (Garst and McCawley, 2015). When performing needs assessments, it is also important to understand what kinds of needs will be explored, and whether they will be felt (is known within the group), unfelt (is not known to the group), or ascribed (an artificial needs that the group may not have known existed) (Rothman and Grant, 1987).

In Cooperative Extension program development, needs assessments can be used to improve accessibility of programs to stakeholders, provide information about present conditions and specific needs of a community, identify opportunities to develop or expand existing programs, and develop programs based on the current and immediate needs of individuals and communities (Seevers and Graham, 2012; Garst and McCawley, 2015). The needs assessment also allows Cooperative Extension researchers and educators to make informed decisions about the use of funding and required investments needed to create, maintain, or expand programs, products, and services (Garst and McCawley, 2015). Although numerous models exist, conducting needs assessments through Cooperative Extension generally follows a step-wise process which includes the following phases: 1) define stakeholder needs; 2) assemble a study group, task force, or committee; 3) evaluate available resources; 4) determine current information about the problems, issues, and/or concerns; 5) select the data collection strategy and methods; 6) determine the sampling approach; 7) design and pilot the collection instrument; 8) gather data; 9) analyze data and determine major findings; 10) synthesize major findings and create reports; and 11) disseminate findings (Garst and McCawley, 2015).
Prior to, or during the initial phases of the needs assessment, the formulation of set objectives and goals can provide a framework to help guide researchers through the phases of a needs assessment. Goals or objectives can be developed using the S.M.A.R.T. method, which is an acronym used to guide researchers in writing specific, measurable, assigned, realistic, and timely goals or objectives (Doran, 1981). Following the completion of the early needs assessment phases, researchers must choose a method or instrument of data collection. Needs assessments generally utilize one or a combination of data collection instruments, including: surveys, interviews, focus groups, and working groups, which can be used to gather communicative and interactive sources of information (McCawley, 2009; Witkin and Altschuld, 1995). The collection of archival or analytic data, from sources, such as records, logs, demographic data, or census data of the target group of interest, can also aid in the development of a data collection instrument (Witkin and Altschuld, 1995). Regardless of the instrument chosen, careful planning during the development phase is critical to reduce potential error, increase reliability, and ensure validity of the developed instrument.

Effects from sampling, sample size, threats to external and internal validity, as well as the reliability of the tool itself, are important factors to evaluate prior to implementing the developed instrument (Witkin and Altschuld, 1995). External validity is a term used to describe whether the results of a study can be generalized to an entire population (Huitt et al., 1999). Factors such as the population, sample, response rates, and the timing in which participants respond during data collection can all impact the external validity of an instrument, such as a survey (Radhakrishna and Doamekpor, 2008). In contrast, internal validity refers to whether the data collection instrument and methods used can accurately produce results, which can conclude that the independent variable being measured produces the observed changes or differences (Huitt et
al., 1999). Threats to internal validity can include biases from history, maturation, testing, statistical regression, instrumentation, mortality, and selection biases.

In addition to validity threats, the reliability of the data collection instrument also is key to ensure the collected data are accurate and precise (Norland-Tilburg, 1990; Radhakrishna, 2007). The use of a pilot test can aid in determining whether the instrument is consistently measuring what it is designed to measure (Radhakrishna, 2007). The utilization of a pilot test generally involves choosing a random subset or sample of the target group that will perform or use the developed data collection tool. A pilot test can help identify unforeseen errors and determine whether a developed data collection tool is effective and useful; ultimately refining the instrument and methods (McCawley, 2009). Statistical reliability tests, such as the test-retest, split-half, and Cronbach’s alpha, can be used to quantitatively assess the reliability of data collection instruments such as surveys and questionnaires (Radhakrishna, 2007). Overall, the use of appropriate needs assessment methodologies and tools, and the planning and utilization of those methods, will ultimately provide researchers with valid and precise needs assessment results to make practical decisions based on identified needs.

**Survey development and methodology**

Historically, the term survey has referred to the study of a population through observation of its members (Jansen, 2010). Alternatively, the modern use of surveys are focused on measuring population characteristics by gathering information on a sample of entities for the purpose of evaluating attributes of the larger population (Jansen, 2010; Groves et al., 2004). Traditionally, surveys or questionnaires have been viewed as the best methods to gather data from a population sample and allow for the organized collection of attitudes, opinions, knowledge, demographics, behaviors, or relationships between chosen variables (Burges, 1976).
The design of surveys should be based on whether the goal is to collect exploratory information for the purpose of better understanding a population or subject, or quantitative information used to test specific hypotheses (Crawford, 1997). Exploratory surveys may utilize less formal question types such as open-ended or interview style questions to avoid restricting the information gathered from a subject (Crawford, 1997). However, if the goal is to test hypotheses and statistically analyze survey responses, formal standardized questions might be used to ensure subjects are provided with the same prescribed wording, order of questions, format, and available responses to specific questions (Crawford, 1997). In general, well designed surveys should meet the research objectives, obtain the most complete and accurate information possible, be easy for respondents to provide the necessary information, and be as brief and to the point as possible (Crawford, 1997). To accomplish these outcomes, researchers must focus on specific elements of the survey or questionnaire including: question content, question wording, style of question, and physical appearance of the survey (Crawford, 1997).

Modern technologies have continued to change the landscape of social science research methods, and it is now commonplace for surveys to be developed and implemented over the internet rather than using paper-based, face-to-face, or telephone-based methods (Crawford, 1997). Compared to paper-based surveys, web-based surveys can greatly reduce cost, improve data quality, decrease the time required to administer a survey, increase subject interaction, and potentially increase the ability to reach a larger population in a shorter period of time (Ekman et al., 2006). However, regardless of the convenience or advantages of each survey method, it is more important to utilize a survey method which is most appropriate to meet the goals of the study. For instance, paper-based or web-based surveys are least useful when researchers require a low response rate, but large amounts of open ended responses or discussion based involvement
from a target population (Burges, 1976). Alternatively, telephone interviews are an inexpensive, yet effective method for administering open-ended, discussion based surveys; while the use of random, digitized calling can also ensure random sampling and access to a large sample of the population (Burges, 1976). Similarly, face-to-face surveys or interviews can offer researchers a broad perspective on a target population, while allowing the interviewer to view nonverbal cues, receive immediate feedback, and allow for clarification of survey questions (McCawley, 2009).

Focus Groups

The use of focus groups as part of a needs assessment can be a powerful tool to gain insight, learn, and further understand an issue or topic effecting a select population of people. Since the late 1930s, social scientists began to explore other ways to conduct interviews, thus developing the focus group method (Krueger and Casey, 2009). In the traditional one-on-one interview, the questioner takes the lead, and the subject plays a passive role. Therefore, information or important points of view may not be disclosed, given the direction the questioner has taken (Krueger and Casey, 2009). In contrast, the traditional focus group allows the researcher to take a passive role, allowing the respondents to comment on areas they perceive as most important, which ultimately keeps the researcher in-tune with the realities of the respondent (Krueger and Casey, 2009).

Today, focus group studies have evolved to suit numerous disciplines. In general, a focus group is viewed as a carefully planned series of discussions designed to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment (Krueger and Casey, 2009). The primary goal of a focus group is to generate participant discussion to increase the depth of the inquiry, unveil aspects of a topic otherwise unknown, accentuate participant’s similarities and differences, and provide information on the range of perspectives and experiences of the
population sample (Freeman et al. 2001; van Eik and Baum 2003; Duggleby 2005; Lambert and Loiselle, 2008). Typically, focus groups are led by an experienced moderator, following a pre-determined and sequenced set of questions called a “question route” (Krueger and Casey, 2009). Generally, question routes consist of 8-10 questions, and the number of participants should range from 5-10 to allow for maximum participation and be conducive for a productive discussion (Krueger and Casey, 2009). Questions used in the beginning of a focus group session should be designed to be more general, while each consecutive question becomes more specific and focused (Krueger and Casey, 2009).

In this setting, there is no pressure to reach a consensus, and instead, the attention is focused on understanding the feelings, comments, and thought processes of the participants on a particular topic (Krueger and Casey, 2009). Although focus groups can be a suitable instrument for needs assessments and program development, focus groups can cause participants to intellectualize, make up answers, feel the need to agree with the group, and produce trivial or unreliable results (Krueger and Casey, 2009). Due to these issues, careful planning is critical to ensure the focus group study produces results to support the purpose and goals of the study. Data collected from a focus group may consist of notes taken by the moderator and an audio or video recording transcribed into writing for further analysis. Due to the open ended nature of focus groups, the type of results analysis will depend on the purpose and goals of the overall assessment or study. Focus group responses can be grouped to find similarities or differences, patterns or relationships can be evaluated, key concepts can be identified, special situations or nuances can be identified, and emotions and body language can be assessed (Krueger and Casey, 2009). Overall, the development, implementation, and analysis of a focus group study should be deliberate, purposeful, systematic, and sequential, ultimately providing the researcher with
valuable, timely, and unique information, not easily attainable through traditional interviews or surveys (Krueger and Casey, 2009).

Direct concealed observations

Researchers studying human behaviors have long been aware and concerned with the effects produced from their study interventions or measurement methods on the objects of their study (Rosenthal, 1966; Lahey, 1982). Direct observation is a method used for evaluating human behaviors in natural settings, and has been used in a variety of fields such as education, human health, and childcare (Dubey et al., 1977; Gittelsohn et al., 1997; Harris, 1982; Maisto and Clifford, 2000). In the area of food safety, direct observations also have been used to identify high-risk behaviors of consumers and retail food operators (Worsfold and Griffith, 1997; Redmond et al., 2006; Richard et al., 2013; Behnke et al., 2012; McIntyre et al., 2014). Direct observations are particularly useful in human behavior research because in practice, there is a significant difference between what people say they do, or did, and what they actually do (Ricci et al., 1995; Gittelsohn et al., 1997). Surveyed or interviewed study participants may forget the kinds of behaviors or actions they may have taken, change and self-report their behaviors or actions based on what they think the interviewer wants to hear, or state what they perceive is most appropriate. (Bentley, 1991; Gittelsohn et al., 1997).

Direct observations also have the advantage of capturing “behavior streams,” which are described as a series of behaviors, each potentially influenced by the behavior it proceeded (Gittelsohn et al., 1997). Despite these advantages, one main problem faced during direct observational studies is the concept of reactivity (Gittelsohn et al., 1997; Baum et al., 1979). The unintended behavior changes that can occur when individuals are knowingly being observed or evaluated is referred to as a reactivity effect. More specifically, a reactivity effect in which
individuals change their behavior in a manner they expect will be favorable to the researcher or person who is conducting the observations is referred to as the Hawthorne Effect (Wickstrom and Bendix, 2000; Machado et al., 2015). One way to avoid the Hawthorne Effect during observational research is to utilize direct concealed observations or mystery shopping methods (Wilson, 2001).

During direct concealed observations, the observed individuals are unaware they are being observed, while the observer records their behaviors in concealment, thus avoiding unintended behavioral changes (Wilson, 2001; Machado et al., 2015). The use of direct concealed observations has been used in a variety of settings and fields of research to record behaviors of medical professionals, temporary retail food handlers, retail deli workers, farmers’ market vendors, and college students (Richard et al., 2013; Behnke et al., 2012; McIntyre et al., 2014; Vandeputte et al., 2015; Hammill and Fojo, 2013). Traditionally, data collection methods used during direct concealed observations have involved the use of a paper-based checklist or recordings, memorizing observations and making recordings out of sight of participants, notational analysis, and most recently, smartphone survey software (Machado et al., 2015; Behnke et al., 2012; Tossell et al., 2012; Vandeputte et al., 2015.). Smartphones, in particular, have been shown to be an incredibly versatile and effective means of recording concealed observations, due in part to the ubiquitous nature of smartphone usage and their ability to be programmed and modified to capture written, audio, photographic, and videographic data (Machado et al., 2015; Vandeputte et al., 2015; Behnke et al., 2012). Through technological advances like smartphones and the associated observational recording software now available, researchers now have more capabilities to perform observational research in a variety of environments and with the ease of using a smartphone.
Food safety training development and assessments

When discussing the development and effectiveness of adult food safety training programs, it is important to first distinguish the meanings and usage of the terms “training,” “education,” and “learning.” Interestingly, adult education specialists have described the idea of training in many ways, but have not reached a consensus (Tight, 1996). Nevertheless, training is typically associated with the preparation of an individual to perform a task or role, and the acquisition of skills, rules, concepts, or attitudes which result in improved performance in the work setting (Goldstein and Gessner, 1988; Peters, 1967; Tight, 1996). In contrast, education is typically associated with a broader and deeper learning activity, which is less focused on development of specific skills. (Tight, 1996). While both the goal of training and education is to create learning on the part of the student or trainee, the concepts of learning and learning theories is complex, less clear-cut, and is heavily debated amongst learning theorists (Tight, 1996). Due to this complexity, most adult educators and trainers give less attention to learning theory and approach education and training heuristically; repeating what works, and eliminating elements of programs that are ineffective (Tight, 1996; Brookfield, 1986; Buckley and Caple, 1990; Rogers, 2001).

Sources have estimated that U. S. organizations spent $164.2 billion on employee learning and development in 2012 (Anonymous, 2013b). In the retail food industry, adult education and training are key components of successful and safe operations, however the continuous evolution of U. S. regulations and health and sanitary standards have created significant challenges for employee training and certifications. World-wide, numerous food safety training programs have been developed, tested, implemented, and evaluated. To this end,
it is has been generally accepted that effectively trained employees and managers can reduce the occurrence of foodborne illness at the retail level (Medeiros et al., 2011; Soon et al., 2012).

In two comprehensive reviews and meta-analyses of studies related to food safety and hygiene training for employees, researchers concluded that as a whole, effective food safety training increases food safety-related knowledge and attitudes, while improving skills and behaviors of employees (Medeiros et al., 2011; Soon et al., 2012). The meta-analysis performed by Soon et al. (2012) also revealed that training effects were largest for participants who were exposed to both a standard model of training, in addition to a behavioral intervention. Medeiros et al. (2011) found that among reviewed food safety training studies, training assessments using pre-and post-test methods, as well as observations of behaviors in the workplace, were most common. A majority (64%) of studies utilized questionnaires to assess knowledge changes throughout the training, with hand-washing and hygiene-related practices being the most commonly-assessed behavior (Medeiros et al., 2011). Among studies reviewed by Medeiros et al. (2011), 71% utilized audiovisual resources to explain topics, lectures or presentations were made in half (50%) of the training courses, 14% used reading materials or booklets, 29% used hands-on activities, 100% of the programs reported the use of gloves and thermometers, and the duration of studies ranged from 1 hour to 3 days of training.

In some cases, food safety training programs have utilized theoretical models to guide their development and assessment. For instance the Iowa model, evidence-based practice to promote quality care, was used by Singh, (2004) to develop training for hand washing among food handlers. Other studies have utilized government training models, such as the Food and Drug Administration’s (FDA) hand washing protocol and the World Health Organization’s (WHO) hygiene training materials (Malhotra et al., 2008; Lillquist et al., 2005). In 2009,
Seaman introduced the Food Hygiene Training Model, improving upon the Tones’ Health Action Model Applied to Food Hygiene Education (Seaman, 2010). The use of computer-based or online food safety training methods and programs also have become commonplace. Training programs such as ServSafe, AIB International, Training Achievement Programs (TAPs Series), Alchemy systems, and Food Marketing Institute’s Super Safe Mark Program, are all examples of current retail food safety training programs available online (Neal et al., 2011).

Despite the overabundance of food safety training programs, researchers have demonstrated that they do not always translate into positive food-handling practices (Green and Selman, 2005; Powell et al., 1997; Clayton et al., 2002). Due to these issues, Neal et al. (2011) also discussed the need for evaluations of food safety training software and programs, to ensure that the programs meet the needs of individual companies and are instructionally sound. In particular, current available retail food safety training programs may not be suitable for workers and vendors of direct-to-consumer retail outlets, such as farmers’ markets, or mobile retail outlets like food trucks. Regardless of the models and methods used, future training programs in food safety should be specific and customized to the needs of the industry being trained, rather than utilizing the same methods across the entire retail food sector.

*Escherichia coli*

**Historical information**

In 1885, Theodore Escherich lectured in Munich to the Society for Morphology and Physiology about new bacteriological methods and findings on an organism he had isolated from infant stool samples called *Bacillus coli commune* (Shulman et al., 2007). In Escherich’s postdoctoral thesis entitled, “The Intestinal Bacteria of the Infant and Their Relation to the Physiology of Digestion,” Escherich describes his use of Christian Gram’s new staining technique
and newly developed anaerobic culture methods to describe the morphology and metabolism of bacteria isolated from infant stool (Shulman, 2007). It was not until 1958, that the name of *Bacillus coli commune* was officially renamed to *Escherichia coli*, in honor of Theodore Escherich’s famous research (Shulman, 2007).

Since its discovery, *E. coli* has become one of the most widely studied and utilized microorganism in the biological sciences (Blount, 2015). *E. coli* is hardy, versatile, can grow rapidly on many different nutrients, and can be isolated from both human and numerous species of animals (Blount, 2015). These traits are what has kept *E. coli* relevant in modern microbiology, and why it has been used in some of the most groundbreaking studies in history on bacterial physiology, viruses, and genetics (Blount, 2015; Daegelen et al., 2009). Since its discovery, researchers have uncovered *E. coli*’s ability to play a role in human gut health, its adaptations and abilities to survive in the external environment, while also being one of the most impactful bacterial human pathogens in the world (van Elsas et al, 2011; Lawrence and Roth, 1996; Kaper et al., 2004; Blount, 2015).

Detection and classification methods for *E. coli* also have evolved throughout history, and continue to change as new technologies and methods reveal the genetic diversity of the organism. Early pioneers in *E. coli* research utilized biochemical tests to differentiate *E. coli* and other organisms by their abilities to metabolize various nutrients and chemicals (Ewing, 1963, Nataro and Kaper 1998). By the early 1900s, research led by Karl Landsteiner began the era of serotyping, and by 1916, the Weil-Felix agglutination test was widely used to test for rickettsial infections (Katz, 2011; Cruickshank, 1927). Serological identification of *E. coli* became relevant in 1944 with the proposed Kauffman scheme which organized *E. coli* serotypes based on their O (somatic), H (flagellar), and K (capsular) surface antigens (Nataro and Kaper, 1998).
Throughout the 1960s and early 1970s the use of phenotypic methods, such as the Hep-2 adherence assay, became widely used to identify certain strains of pathogenic *E. coli*, as a result of new available laboratory methods and a significant increase in nosocomial infections occurring from gram-negative bacteria in hospital patients (US-EPA, 1997; Nataro and Kaper, 1998). Throughout the late 1970s and early 1980s, advances in bacterial genetics and genotyping led to early phylotyping methods, with the development of multi locus enzyme electrophoresis (MLEE), and other characterization methods based on the presence of proteins and enzymes and their electrophoretic behaviors (Ocman and Selander, 1984). However, it was not until the breakthroughs of Sanger Sequencing in 1977, the Polymerase Chain Reaction in 1983, and the infamous Jack in the Box *E. coli* O157:H7 outbreak in 1993, that significant leaps and support for further *E. coli* characterization and subtyping methods occurred (Sanger et al., 1977; Bartlett and Stirling, 2003).

Since those significant events, the use of DNA sequencing and other molecular subtyping methods, such as ribotyping, Pulse Field Gel Electrophoresis (PFGE), Multi Locus Sequence Typing (MLST), Multi Loci Variable Number of Tandem Repeat Analysis (MLVA), Clermont’s phylotyping method, and Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) analysis, to identify and subtype *E. coli* strains have become common place. In this new era of molecular subtyping, the characterization of *E. coli* is much less standardized and much more contested within the scientific community. However, the new knowledge gained through the use of these methods has been vast. It is now common for researchers to use a variety of subtyping methods to identify and explore the intricacies and diversity of *E. coli*. Furthermore, government regulatory agencies, such as the FDA and USDA, continue to experiment, modify, and test new technologies to better characterize *E. coli* isolates during outbreaks, and further understand the
continued evolution and survival of the organism through survey studies (USDA-FSIS, 2015b; FDA, 2015). Future *E. coli* research will no doubt face a challenge in selecting methods and tools to use during the study of *E. coli*, as new technologies continue to develop and shape the scientific communities understanding of the bacteria’s survival, infection, evolution, and physiology.

**Characteristics of *Escherichia coli***

*E. coli* is a member of the Enterobacteriaceae family, which is comprised of Gram-negative facultative anaerobic bacteria, many of which can be found in the normal gut microflora of humans and animals (Holt et al., 1994). Although the most well studied and notorious strains of *E. coli* are pathogenic, the majority of the species is considered harmless, acting as a commensal organism in the gastro-intestinal tract of warm-blooded animals, and surviving in various external environmental sources (Croxen et al., 2013; Donnenberg, 2013). Other notable species of the genus *Escherichia* include: *E. fergusonii*, *E. blattae*, *E. vulneris*, and *E. hermannii*. However, recent phylogenetic and MLST analysis has revealed that *E. blattae*, *E. vulneris*, and *E. hermannii* are distantly related to *E. coli*, and may not be valid members of the genus *Escherichia* (Donnenberg, 2013; Walk et al., 2009). With the exception of *E. blattae*, these other species of *Escherichia* are considered rare opportunistic pathogens, typically associated with wound infections (Holt et al., 1994).

*E. coli* morphology can be described as straight rods, 1.1-1.5 μm x 2.0-6.0 μm in size, single bacteria or in pairs, and utilize pertrichous flagella for motility, though some strains are non-motile (Holt et al., 1994). *E. coli* utilizes both a respiratory and a fermentative type of metabolism and grows optimally at 37°C. However, previous research has demonstrated certain strains can grow as low as 19°C and as high as 46°C (Holt et al., 1994; Raghubeer and Matches,
Traditionally, *E. coli* is identified through biochemical metabolic tests and further characterized serologically. *E. coli* is oxidase negative, catalase positive, methyl red positive, Voges-Proskauer negative, indole positive, and citrate negative. Based on the original works by Parr, (1936), successful identification of *E. coli* within the coliform group is achieved using 4 biochemical tests, which together show the greatest discrimination, as compared to other combinations of biochemical tests. These 4 tests include the indole, methyl red, Voges Proskauer and citrate tests, which when used together are referred to as the IMViC test.

In the original works by Geldreich et al. (1958), among 5,794 cultures of coliform bacteria which grew in *E. coli* (EC) medium at 45°C, 92% and 22% of *E. coli* yielded an IMViC pattern of (+ + - -) and (- + - -), respectively. Based on these early works, the IMViC test still used today classifies *E. coli* as either Biotypes I or II based on the two validated IMViC patterns first established in 1936. In addition to biochemical confirmation, following the development of the Kaufman classification scheme in the 1950s, and further modified by Orskov in the 1980s, *E. coli* can be further subdivided based on the presence of O (somatic) polysaccharides, H (flagellar), and K (capsular) surface antigens, known as serotyping (Croxen et al., 2013, Nataro, 1998; Orskov and Orskov, 1992). Currently, there are 174 known *E. coli* O antigens, 56 H antigens, and 80 K antigens; however, new antigens continue to be revealed (Wang et al., 2003; DebRoy et al., 2011; Orskov and Orskov, 1992; Tenaillon et al., 2010).

Whole genome sequencing analysis on 20 different *E. coli* strains has revealed that the *E. coli* genome contains on average 4,721 genes, with 2,000 genes conserved among all strains of *E. coli*, comprising what is referred to as the core genome (Touchon et al., 2009; Hendrickson, 2009). However, over 17,000 total genes have been identified from the collection of *E. coli* genomes, encompassing what is known as the pan-genome (Touchon et al., 2009; Hendrickson, 2009).
Interestingly, among 21 genomes analyzed by Touchon et al. (2009), 133 loci were identified to account for 71% of the non-core pan-genome genes. It has been suggested that the identified non-homologous genome regions may be the result of single integration events leading to a higher rate of recombination and horizontal gene transfer (Touchon et al., 2009; Hendrickson, 2009). Additional linkage disequilibrium analysis by Touchon et al. (2009) performed on the alignment of the same 20 *E. coli* core genomes revealed a high level of gene conversion, demonstrating that any single nucleotide was 100 times more likely to be involved in gene transfer than mutation (Hendrickson, 2009). Researchers have hypothesized that these results are evidence of the clonal population structure of *E. coli*, which accounts for the genetic relationship observed between strains, and supports the usefulness of phylogenetic analysis to organize and study commensal *E. coli* (Hendrickson, 2009).

**Commensal *E. coli***

The surge in research related to the human gut microflora and its significance to human health has generated an extensive interest in understanding the dynamics of bacteria, such as *E. coli*, which can exist both as a pathogen and a harmless commensal of the gut microbial community (Dobrindt et al., 2013; Casadevall and Pirofski, 2000). While the term pathogen is generally understood to reflect a harmful microbe that can cause disease, the terms commensalism, carrier state, opportunist, and saprophyte have been used interchangeably to reflect similar attributes of a commensal organism (Casadevall and Pirofski, 2000). As research has revealed that the host-pathogen interaction does not always lead to disease, commensalism has become widely used to explain states in which microbes can exist in certain hosts without causing disease, and in some cases, be beneficial (Dobrindt et al., 2013; Casadevall and Pirofski, 2000). The Latin roots of the term commensalism, literally translates to “eating at the same table” (Casadevall and Pirofski,
Based on this translation some researchers define commensalism as a “host-microbial interaction that does not result in perceptible, ongoing, and/or persistent host damage” (Casadevall and Pirofski, 2000). While this definition may be suitable, recent research has provided evidence that commensal strains of \textit{E. coli}, may acquire virulence genes as part of the natural survival and evolution, potentially becoming pathogenic, or as a pathogen reverting back to a commensal state through the loss of virulence genes (Stecher et al., 2012; Wassenaar and Gunzer, 2015).

Typically, population studies of commensal \textit{E. coli} have utilized phylogenetic tools based on the original MLEE analysis used to develop the \textit{E. coli} reference strain collection (ECOR), established by Ochman and Selander, (1984). Within this structure, \textit{E. coli} are organized into groups, based on the electrophoretic profiles of 11 house-keeping enzymes (Ochman and Selander, 1984). Since the original creation of the \textit{E. coli} reference strain collection, researchers have modified the scheme using multiplex PCR and MLST methods, although surprisingly the original classifications tend to hold true (Dobrindt et al., 2013; Clermont et al., 2013). Using the recently updated methods by Clermont et al., (2013), \textit{E. coli} can be phylogenetically organized into 7 groups (A, B1, B2, C, D, E, F), based on the presence of 4 gene targets, \textit{arpA}, \textit{chuA}, \textit{yjaA}, TspE4.C2, or into 5 rare cryptic clades, based on the presence of 2 additional gene targets in \textit{aes} and \textit{chuA} (Clermont et al., 2011). MLST analysis is necessary when isolates do not fit into the prescribed assignments. It is important to note that the cryptic clades, isolates which require this additional MLST analysis, have been found to be rare (Clermont et al., 2013; Dobrindt et al., 2013).

**Phylogenetic Clustering of Commensal \textit{E. coli}**

It has been hypothesized that commensal strains of \textit{E. coli} may adapt to a lifestyle of “commensal minimalism,” whereby unnecessary or virulence genes are shed, leading to a smaller
genome when compared to pathogenic strains (Sims and Kim, 2011). There also is evidence that 
*E. coli* phylogroups have been associated with specific commensal gut niches (Dixit et al., 2004). Researchers studying the prevalence of commensal *E. coli* phylogroups in the porcine gastrointestinal tract found that 76% and 42% of *E. coli* isolates (n=121) from the duodenum, ileum, and colon, grouped into phylogroups A and B, respectively, while only 58% and 24% of phylogroup A and B isolates, respectively, were found in feces (Dixit et al., 2004). Similarly, numerous studies have provided evidence that the distribution of *E. coli* clustering into certain phylogroups can be similar among the same host type-with certain phylogroups found to be more frequently isolated from humans, versus livestock, plants, wild animals, etc. For instance, Lescat et al. (2013) collected *E. coli* isolates from French Guiana residents, livestock, and wild animals, and found that phylogroups A and B1 comprised the 54% and 24% of human isolates, respectively. Phylogroups B1, B2, and D made up 52.4%, 10%, and 10%, respectively of livestock, while groups B2, B1 comprised of 46% and 25% of wild animal isolates, respectively (Lescat et al., 2013).

Bailey et al. (2010) also found that *E. coli* in group A were expressed in 1,889 human stool samples. Analysis of *E. coli* isolated from seagull feces in Portugal revealed that the majority of isolates were grouped into phylogroups B1 and D (Simoes et al., 2010). Most recently, Meric et al. (2013) assessed the phylogenetic distribution of *E. coli* isolated (n=106) from salad crops grown in England and reported that the majority clustered into phylogroup B1 (48%), with fewer isolates clustering into A (21%), D (15%), B2 (12%), and E (3%). The same study assessed the ability of those isolates to form biofilms and metabolize 18 different carbon sources, while correlating those results with the phylogenetic analysis. Meric et al. (2013) demonstrated that isolates clustered into phylogroup B1 had a significantly higher association with the phenotypic traits measured, compared to the other less abundant phylogroups, providing further evidence that *E. coli* are not
randomly distributed into phylogroups. More research is needed to determine the distribution of *E. coli* phylogroups among *E. coli* isolated from uninvestigated environmental, plant, and animal sources, which could advance the understanding of *E. coli* ecology, survival, and distribution.

**E. coli** pathotypes

Although *E. coli* isolates are generally organized and clustered, based on their biochemical, serological, phylogenetic, or genomic characteristics, pathogenic *E. coli* also have been grouped into a system of pathotypes. In general terms, an *E. coli* pathotype is a system of grouping pathogenic *E. coli*, based on both the genotypic and phenotypic characteristics, and more specifically, by the type of illness caused and the mode of action used to cause the illness (Donnenberg, 2013). *E. coli* pathotypes are split into two separate higher order groupings, named extra-intestinal pathogenic *E. coli* (ExPEC) and intestinal pathogenic *E. coli* (IPEC or InPEC). In recent history, pathotype determination has been strengthened by use of virulence gene presence, in addition to the clinical disease manifestations (Dobrindt et al., 2013). To date, several pathotypes exist within the IPEC grouping, including: enteroaggregative *E. coli* (EAEC), enterohaemorrhagic *E. coli* (EHEC), enteroinvasive *E. coli* (EIEC), enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC), diffusely adherent *E. coli* (DAEC), and adherent invasive *E. coli* (AIEC) (Croxen et al., 2013; Dobrindt et al., 2013). The most common ExPEC pathotypes include: uropathogenic *E. coli* (UPEC), meningitis-associated *E. coli* (MNEC), septicemia-associated *E. coli* (SEPEC), and avian pathogenic *E. coli* (APEC) (Croxen et al., 2013; Dobrindt et al., 2013).

To date, no study has found a direct correlation between pathotype and phylogenetic lineage, and comparisons of genome coverage between IPEC, ExPEC, and commensal *E. coli* reveal no overlaps (Dobrindt et al., 2013). It is suspected that each pathotype has evolved in
parallel evolution, forming phylogenetic clades, and acquiring genes via extensive horizontal gene transfer events, thus forming similar pathotypes between phylogroups. (Dobrindt et al., 2013). For example, the infamous *E. coli* O157:H7 EHEC strain is hypothesized to have evolved from an O55:H7 EHEC precursor by acquiring the phage-encoded Shiga toxin virulence factor (Dobrindt et al., 2013). Genetic analysis has shown the close phylogenetic clustering of the two strains, further reinforcing this hypothesis (Dobrindt et al., 2013).

Overall, IPEC pathotypes have been studied in much greater detail than ExPEC, whereby the virulence factors required to classify each IPEC pathotype are much more standardized and accepted within the scientific community (Kaper et al., 2004). ExPEC strains and the virulence factors required for those strains to become pathogenic are much less understood. Currently the convention within the *E. coli* research community is to classify an *E. coli* strain as ExPEC, based on the origin of isolation and the detection of at least two virulence-associated genes typical of the specific pathotype (Kohler and Dobrindt, 2011). To date, ~28 virulence genes are associated with ExPEC strains, which include genes encoding for adhesins, invasins, iron chelators, toxins, protectins, flagella, and membrane transporters (Kohler and Dobrindt, 2011). It is hypothesized that extraintestinal virulence may be a random result of natural commensalism, whereby the identified ExPEC virulence factors guard against predation in the environment and allow for successful colonization of human membranes (Tenaillon et al., 2010; Le Gall et al., 2007; Kohler and Dobrindt, 2011). Future research is necessary to further understand the relationship and life cycles of ExPEC strains from uninvestigated hosts and sources, in addition to increasing the knowledge of phylogenetic relationships between newly identified ExPEC strains.
**E. coli infections in humans**

**Epidemiological significance**

In many regions of the world, diarrheal illness is a major cause of mortality for children under the age of 5, and in some cases, causing more than 50,000 deaths per year (Croxen et al., 2013; WHO, 2012). Pathogenic *E. coli* is one of the major contributors to these deaths, with enterotoxigenic *E. coli* being one of three major etiological agents, causing pediatric diarrheal illness in sub-Saharan Africa and South Asia (Croxen et al., 2013; Kotloff et al., 2013). In the U. S., culture-confirmed cases of pathogenic enteric *E. coli*, reported by the CDC, accounted for over 1000 illnesses, 286 hospitalizations, 62 cases of hemolytic uremic syndrome (HUS), and 2 deaths in 2012 (CDC, 2014). However, statistical estimates accounting for under reporting and under diagnosis calculated by Scallan et al. (2011), predict that over 344,000 diarrheal illnesses are caused by pathogenic *E. coli* in the U. S. annually.

Non-diarrheal-causing, pathogenic *E. coli* are also a serious problem in the U. S., causing a diverse spectrum of infections including: sepsis, meningitis, and urinary tract infections (UTI) (Mellata, 2013). In the U. S., it has been estimated that over 8 million people contract ExPEC infections annually (Mellata, 2013; Russo and Johnson, 2003). In 2001 alone, *E. coli* septicemia caused 40,000 deaths, and is estimated to be responsible for 30% of all sepsis cases in the U. S (Russo and Johnson, 2003; Mellata, 2013).

UPEC is estimated to account for 70-90% of all community-acquired UTIs in the U. S., with incidence rates 4 times higher in women than men (Mellata, 2013; Pitout, 2012; Griebling, 2007). Newborns are particularly susceptible to ExPEC infections, which can occur during or shortly after delivery (Mellata, 2013). In fact, neonatal sepsis has been considered one of the top 5 leading neonatal infections in the world, with *E. coli* being one of two of the major causes of
the disease in the U. S. (Stoll et al., 2011; Mellata, 2013). Recent studies also have revealed that human ExPEC strains have developed resistance to common first-line antibiotics, including: cephalosporins, fluoroquinolones, and sulfamethoxazole/trimethoprim (Pitout, 2012).

Interestingly, similar antibiotic resistance and virulence profiles have been observed in avian pathogenic E. coli (APEC) strains, which cause a wide variety of illnesses in chicken and turkey flocks in the U. S. and worldwide (Zhao et al., 2005). It has been hypothesized that antibiotic-resistant, human ExPEC may have originated from poultry, either through direct contact or through consumption of poultry meat. However, this hypothesis continues to be challenged within the scientific community (Manges and Johnson, 2012).

Disease characteristics and pathogenesis

The characteristics of pathogenic E. coli infections can vary considerably, depending on the pathotype and virulence factors acquired by the individual strain. Enteric strains which include EAEC, EHEC, EIEC, EPEC, ETEC, DAEC, and AIEC overall cause pathotype-dependent symptoms, which can include diarrhea (profuse water, persistent, or bloody), hemorrhagic colitis, HUS, and in the case of AIEC, Crohn’s disease (Croxen et al., 2013). In general, infections caused by enteric pathotypes are the result of consumption of contaminated food and/or water, although contact with infected individuals can also result in infections (Croxen et al., 2013). Following consumption of contaminated food or water, enteric E. coli pathotypes can colonize the small intestine, colon, or distal ileum, depending on the pathotype (Croxen et al., 2013). Although the infection mode of action and use of virulence factors overlap between the enteric pathotypes, each pathotype has distinct characteristics, resulting in variable symptoms and illnesses. Depending on the pathotype, disease characteristics can include: the development of distinct lesions on epithelial cells (EPEC); attachment to epithelial cells and
production of Shiga-toxin (STEC, EHEC); invasion into epithelial cells and production of enterotoxins (EIEC); aggregative adherence to intestinal mucosa, intestinal inflammation, and production of putative toxins (EAEC); attachment to epithelial linings and production of enterotoxins (ETEC); scattered adherence to epithelial HeP-2 cells and internalization into epithelial cells (DAEC).

Compared to enteric pathogenic E. coli, ExPEC pathotypes such as UPEC, SEPEC, and MNEC, are much less understood; however, their varied pathogenesis has been characterized in recent studies. In the case of UPEC, infectious strains adhere to the urinary tract epithelium mediated through fimbriae, and over the course of their colonization, secrete a series of toxins which kill the host’s epithelial cells, causing the symptoms of a UTI (Ulett et al., 2013). Meningitis-associated E. coli infections are less clear cut. Using animal models and human case studies, researchers have concluded that meningitis-associated E. coli infections first require the development of bacteremia at high concentrations (Donnenberg, 2013). Traversing through the blood-brain barrier is not completely understood, although research has identified specific virulence factors (type 1 fimbriae, flagella, outer membrane protein A, lipoprotein) which are necessary for meningitis development (Donnenberg, 2013).

E. coli in the food supply

Since 2006, 22 major multi-state outbreaks of pathogenic E. coli have occurred in the U. S. (CDC, 2015a). Contaminated foods associated with these outbreaks have included produce (raw sprouts, bagged salads, lettuce, spinach), meat (ground beef, beef patties, Lebanon bologna, sliced pepperoni), and other foods (hazelnuts, cheese, cookie dough, microwavable meals) (CDC, 2015a). Interestingly, beef products which are typically associated with pathogenic E. coli contamination, have accounted for only 6/22 multi-state outbreaks since 2006, suggesting that
contamination sources may be more diverse than previously suspected (CDC, 2015a). Enhanced regulatory pressures and a proactive meat processing industry also may account for the reduced occurrence of meat-related, multi-state pathogenic *E. coli* outbreaks in the U. S. In fact, USDA-FSIS ground beef and beef trim routine testing results between 2011 to date have shown an STEC prevalence rate ranging from 0-2% (USDA-FSIS, 2015b).

In contrast, recent studies have revealed the presence of *E. coli* and specifically STEC in raw and RTE meat products sampled from retail sources. Svoboda et al. (2013), found that among 118 samples of ground beef sampled from processing plants and retail stores in Pennsylvania, ~18% were positive for STEC-related O-groups; however, no samples were positive for Shiga-toxin producing genes. Researchers performing a survey study of Washington D.C. retail meat samples reported that among 249 ground beef and 231 ground pork samples, confirmed STEC was isolated from 5% of both beef and pork samples (Ju et al., 2012). In a related study, Magwedere et al. (2013) reported that among ground beef and pork samples obtained from Pennsylvania and Virginia supermarkets, 35% and 50% of ground beef and pork were positive for STEC-related O-groups, with no samples positive for Shiga-toxin genes. Although the presence of pathogenic *E. coli* in various foods has been the focus of a majority of recent retail meat survey studies, one largescale seven year, multi-state study examined the prevalence of generic *E. coli* in 11,921 retail meat and poultry samples obtained from supermarkets between 2002-2008 (Zhao et al., 2012). Over the seven year period, *E. coli* was found to be present in 84% of chicken breast samples (n=2,988), 69% of ground beef samples (n=2,991), and 44% of pork chop samples (n=3,000) (Zhao et al., 2012). These results suggest that while STEC control in the meat industry appears to be successful, non-STEC *E. coli* are still persisting through processing and can be isolated from meat products at retail.
While the meat industry continues to endure increased oversight, regulation, and public health demands focused on specific pathogens like STEC, these same requirements have not been applied to foods such as fresh produce. In fact, a historical lack of oversight and ageing policies may be a factor for the increase in the rate of outbreaks associated with fresh produce. A recent CDC report stated that among all reported outbreaks occurring from 1998-2008, 46% of illnesses were attributed to commercially sold produce, with leafy-green vegetables having the highest association with outbreaks compared to other produce commodities (Painter et al., 2013). Survey studies examining the prevalence of generic and pathogenic *E. coli* present in fresh produce have revealed variable results.

Mukherjee et al. (2006) collected organic, semi-organic, and conventional produce from 24 farms in Minnesota and Wisconsin and found that 15% and 16% of sampled leafy greens (n=296) and lettuces (n=157) were *E. coli* positive. A related study by the same authors performed in 2004, found 5% of sampled tomatoes were positive for *E. coli*, collected from 40 farms in Minnesota (Mukhejeree et al., 2004). Spanish researchers determined that among 72 lettuce samples obtained from conventional and organic Spanish farms, 35% were positive for *E. coli* (Oliveira et al., 2010). Similarly, Bohaychuk et al. (2009) sampled fresh produce sold at 36 farmers’ markets in Alberta, Canada, and found an *E. coli* prevalence rate of 23%, 16% and 0% in lettuce (n=128), spinach (n=59), and tomatoes (n=120), respectively, purchased from Canadian farmers’ market vendors. From 2002-2012, the USDA Agricultural Marketing Service (USDA-AMS) had been collaborating with the CDC, FDA, and 11 state health departments, to determine the prevalence of targeted foodborne pathogens in fresh fruit and vegetables sold in the U. S. through the USDA Microbiological Data Program. The latest summary report released in 2011 stated that 5/2336 (0.2%) of lettuce and 29/2328 (1.2%) of spinach sampled in 2009,
were positive for pathogenic *E. coli*, although generic or commensal *E. coli* prevalence rates were not provided (USDA-AMS, 2011). The samples collected were obtained from wholesale distribution and processing centers in select states, and only included 0, 9 and 27 lettuce and 15, 18, 30 spinach samples from New Jersey, New York, and Pennsylvania, respectively. Although this program collected valuable U. S. surveillance data, over 80% of lettuce and 73% of spinach samples analyzed, originated from California, and may not be a suitable indicator of *E. coli* prevalence in fresh produce originating from the Northeast U. S. (USDA-AMS, 2011).

Unfortunately, few produce outbreak investigations have been successful at identifying the originating source(s) of contamination. Previous studies have found that irrigation water, manure, livestock, wild animals, insects, and human workers, can serve as potential origins of contamination (Bucholz et al., 2014). Historically, pathogenic *E. coli* has remained one of the top three causes of produce-related outbreaks in the U. S., next to norovirus and *Salmonella* (FDA-CFSAN, 1998). In fact, since 2011, three major multi-state outbreaks associated with fresh or bagged produce have occurred, and also were the result of pathogenic *E. coli* contamination (CDC, 2014). Surprisingly, even with the extensive amount of *E. coli* indicator testing performed on water, farms, and food processing facilities, research is still needed to fully understand the ecology and survival of *E. coli* in agricultural environments.

*Listeria monocytogenes*

**Historical information**

Compared to other notorious pathogenic bacteria, studies of *Listeria* spp. did not occur until relatively recent times. In fact, it was not until a series of devastating outbreaks occurring in the 1980s, leading to the deaths of hundreds in U. S. and Europe that researchers and government agencies began to view *Listeria monocytogenes* as a serious threat to public health (Acheson,
The Gram-positive rod was initially identified and named *Bacterium monocytogenes* by E. G. D. Murray, who isolated the bacterium from the blood of rabbits (Murray et al., 1926). Around the same time of its initial identification, the first documented cases of listeriosis occurred in Germany, where scientists observed numerous cases of “granulomatosis infantiseptica” and connatal infections of newborns, and identified *Bacterium monocytogenes* as the causative agent (Hof, 2002). By 1927, *Bacterium monocytogenes*, had been independently identified by several other researchers, one of whom proposed to re-name the bacteria to *Listerella hepatolytica*, after the revered Dr. Joseph Lister (Ryser and Marth, 1999). Interestingly, the Judicial Commission of the International Committee on Systematic Bacteriology not only rejected the initial name change, but would reject 6 more name changes until 1940 when the genus *Listeria* was established (Ryser and Marth, 1999). For the next 40 years, *Listeria monocytogenes* would be regarded mainly as an animal disease, although it was recognized in the 1960s that immunocompromised individuals could contract infections of *L. monocytogenes* (Acheson, 2000). In 1985, one of the deadliest *L. monocytogenes* foodborne outbreaks occurred in the U. S., originating from Mexican style soft cheese, causing 52 deaths including 19 stillbirths and 10 infant deaths (Linnan et al., 1988). Soon after the deadly outbreak, research, surveillance, and regulatory oversight of foods at risk for *Listeria* spp. contamination increased significantly in the U. S. Although control of *L. monocytogenes* continues to be a top priority of U. S. public health agencies today, the CDC estimates that ~1600 illnesses and 260 deaths still occur each year in the U. S. as a result of infections by this bacterium (CDC, 2015b).

**Characteristics of *Listeria* spp.**

The genus *Listeria* is comprised of both non-pathogenic and facultative intracellular pathogenic species able to cause disease in animals and humans (Nightingale et al., 2004; Holt et
Listeria spp. typically appear as Gram-positive short rods, approximately 0.4 µm-0.5 x 0.5-2 µm in size, but can also appear as coccoid-like in certain conditions (Holt, 1994). Listeria spp. can be motile with peritrichous flagella when grown at 20-25°C, and utilize a fermentative metabolism when grown at optimal growth temperatures (30-37°C). Listeria spp., are catalase positive, oxidase negative, non-sporulating, and non-acid fast (Holt et al., 1994). Biochemical differentiation between Listeria spp., can be performed through β-hemolysis test, CAMP test, hippurate hydrolysis, reduction of nitrate, and production of acid from the metabolism of mannitol, α-methyl-D-mannoside, L-Rhamnose, soluble starch, and D-xylose tests (Holt et al., 1994).

Although differences exist between species and strains, overall the genus Listeria spp., is an extremely hardy and versatile bacterium, capable of surviving and growing in various stressful environments. Listeria spp. is said to live both a saprophytic and intracellular pathogenic lifestyle, having been isolated from soil, silage, groundwater, sewage, vegetation, farmed crops, and found to infect a wide range of hosts such as animals and humans (Nightingale et al., 2004; Freitag et al., 2009). Due to its ability to survive in environments of high concentrations of metal ions, salt, and withstand large fluctuations in pH and temperature, Listeria spp. is commonly found to inhabit numerous food processing plants, especially those operating in low temperatures (Nightingale et al., 2004). In fact, L. monocytogenes has been reported to survive and grow in temperatures ranging from 0.4-45°C, while also becoming increasingly thermotolerant after exposure to sub-lethal heating or osmotic and acid shocks (Fleming et al., 1985; Thevenot et al., 2006). While these characteristics make Listeria control difficult, the presence of Listeria spp., is widely used as an indicator of proper hygiene and sanitation in the food production industry (Kornacki, 2011).

Although new population genomic studies continue to challenge the known members of the Listeria genus, the genus of Listeria currently consists of fifteen species (L. monocytogenes,
L. innocua, L. seeligeri, L. welshimeri, L. martihii, L. ivanovii, L. rocourtiae, L. grayi, L. fleischmannii, L. weihenstephanensis, L. floridensis, L. aquatica, L. cornellensis, L. riparia, L. grandensis), and in addition, two subspecies have been identified within L. ivanovii (subsp. Ivanovii and subsp. Murrayi) (den Bakker et al., 2014). Only L. monocytogenes and L. ivanovii are considered pathogenic. However, L. ivanovii is rarely associated with human listeriosis and is mainly viewed as an animal pathogen (Johnson et al., 2004). Since the late 1980s, molecular subtyping methods have been used to further differentiate strains of L. monocytogenes based on a variety of genotypic and phenotypic characteristics (Orsi et al., 2011). L. monocytogenes can be divided into four (I-IV) phylogenetic lineages, determined by MLEE or MLST profiles, consisting of 13 known serotypes (I: 1/2a, 3b, 3c, 4b; II: 1/2a, 1/2c, 3a; III: 4a, 4b, 4c; IV: 4a, 4b, 4c), and the serological (O and H antigens) properties of the bacterium (Orsi et al., 2011). Lineages I and II and serotypes 1/2a, 1/2b, and 4b have been found to be over represented in human and food-related isolates, while lineages III and IV are mostly found in ruminants and are considered rare (Orsi et al., 2011).

**Listeria spp. infections in humans**

**Epidemiological significance**

While the incidence of listeriosis in the U. S. is relatively low, when compared to other foodborne illnesses, the severity of the disease and the high case fatality rate (20-30%) are causes for major public health concerns (Mateus et al., 2013; Allerberger, 2003). Another critical feature of listeriosis is the long incubation period, which has been reported to extend up to 67 days, making outbreak investigations and diagnoses difficult (Goulet et al., 2012). The CDC estimates that the annual listeriosis incidence rate in the U. S. is 0.26 cases per 100,000 (CDC, 2015c). Further statistical estimates, incorporating under reporting and under diagnoses, demonstrate L.
*L. monocytogenes* causes over 1,500 illnesses and ~15 deaths per year in the U. S. (Scallan et al., 2011). Worldwide, *L. monocytogenes* is estimated to cause over 23,000 illnesses, leading to over 5,000 deaths per year (de Noordhout et al., 2014). Additionally, epidemiologists have revealed that high-risk groups, such as adults over 65 and pregnant women, can have infection risks up to 12 times and 20 times higher than healthy adults, respectively (Ogunmodede et al., 2005; Silk et al., 2012). Due to the severity of the infection, listeriosis also causes a severe economic strain on the U. S., costing an estimated $2.3-22 billion in associated medical costs, making it one of the most costly foodborne pathogens in the world (de Noordhout et al., 2014; Ivanek et al., 2004).

**Disease Characteristics and pathogenesis**

In the U. S., the CDC reports that nearly 90% of diagnosed listeriosis cases occur in individuals belonging to high-risk groups (pregnant women, newborns, adults over 65 years of age, immune-compromised individuals), which may account for the high mortality rate associated with *L. monocytogenes* infections (CDC, 2015b). Infections of *L. monocytogenes* normally begin after the consumption of contaminated food, or by infected mother-to-fetus transmission (Donovan et al., 2015). Previous studies have determined that a fairly high concentration of *L. monocytogenes* cells (~9.0 log10) are required to cause infection in humans (Farber et al., 1991). Once ingested, *L. monocytogenes* infects the intestinal epithelial cells utilizing the virulence factor internalin A (*inlA*), allowing the bacterium to traverse epithelial cell layers and travel into the bloodstream where it is able to infect organs and other cells (Pamer, 2004). Utilizing additional virulence factors, internalin A and B (*inlA/inlB*), *L. monocytogenes* is able to attach to host cells in the bloodstream, particularly macrophages, where it becomes internalized. Once internalized, *L. monocytogenes* escapes from cytosolic vacuoles using listeriolysin (*LLO*), becomes released
within the cell cytosol, replicates itself, and then is able to move into adjacent cells using actin polymerization (\textit{actA}), further spreading the infection (Pamer, 2004).

Clinical symptoms of listeriosis typically include fever, headache, neck stiffness, and general flu-like symptoms, depending on the condition of the host (Donovan, 2015). \textit{L. monocytogenes} infections during pregnancy are particularly serious, due to the ability of the bacterium to pass through the placenta and infect the fetus (Donovan, 2015). Although the mother may only experience flu-like symptoms, infections of the fetus can result in preterm labor, stillbirth, and septic abortion (Donovan, 2015). Febrile gastroenteritis is also another clinical manifestation of \textit{L. monocytogenes} infections, characterized as being associated with outbreaks and includes symptoms of fever, vomiting, diarrhea, and myalgia (Ooi and Lorber, 2005; Donovan, 2015). While still remaining relatively uncommon, infections of \textit{L. monocytogenes} can be extremely serious and continue to require significant public health efforts to control and prevent the organism from infecting the public. Since the majority of infections originate from contaminated food, increased surveillance and oversight for the control of \textit{L. monocytogenes} in food production facilities is warranted.

\textit{L. monocytogenes} in the food supply

Since 2011, 9 major U. S. multi-state outbreaks have occurred involving \textit{L. monocytogenes}, which includes the largest outbreak of listeriosis ever recorded in the in the U. S. (CDC, 2015c). In 2011, the infamous Jensen Farm cantaloupe outbreak caused 147 illnesses and 33 deaths across 27 states, leading to the first ever convictions of company owners for “introducing adulterated food into interstate commerce” (CDC, 2015d; Marklein, 2014). Foods involved with the remaining 8 multi-state outbreaks included dairy products (cheeses and ice-cream), mung bean sprouts, and caramel apples (CDC, 2015c). Interestingly, the majority of food products involved
in these multi-state outbreaks are considered RTE foods, which are the types of foods most at risk for *L. monocytogenes* contamination.

Among all food categories, deli meats have consistently been ranked the highest-risk food vehicle for *L. monocytogenes* by various risk assessments (Endrikat et al., 2010). Due to this conclusion, most risk assessments to date have focused sampling efforts on RTE retail deli foods, and few studies have assessed the prevalence of *L. monocytogenes* in other food products. One exception is an ongoing comprehensive survey of *L. monocytogenes* in more than 10 food categories conducted by the USDA-ARS, which reported in 2012 that among 7,500 FDA regulated food samples tested, the prevalence of *L. monocytogenes* was between 0-1% (Luchansky et al., 2012). Those sample categories included smoked seafood, seafood salad, low acid cut fruits, soft cheese, deli salads (non-meat), raw milk, sandwiches, deli meats, deli salads containing meat, and dried/fermented sausage (Luchansky et al., 2012). A similar previous survey performed 11 years prior examined the prevalence of *L. monocytogenes* from 31,705 food items including: fresh soft cheeses, bagged salads, blue-veined cheeses, mold-ripened cheeses, seafood salads, smoked seafood, luncheon meats, and deli salads (Gombas et al., 2003). Overall prevalence rates for all food categories was less than 5%, with 5 of the categories being close to 1% (Gombas et al., 2003). The results of these studies performed nearly a decade apart, clearly demonstrate that despite the continued occurrence of outbreaks, the prevalence of *L. monocytogenes* in tested retail food products remains low.

Outside of RTE meats and prepared foods, raw meat and produce also has been found to harbor *Listeria* spp. at the retail level. Samadpour et al. (2006) collected over 2,000 samples of ground beef, sprouts, and mushrooms from Seattle retail stores, and reported *L. monocytogenes* was present in 3.5% of ground beef (18/512), 0% of sprouts (0/200), and 1% of mushrooms.
A survey of produce obtained from both farmers’ markets and supermarkets performed in the Washington D.C. area reported *Listeria* spp. was present on samples of celery (2/6), field cress (4/11), and potatoes (4/8) (Thunberg et al., 2002). Samples obtained from supermarkets in the same study found *Listeria* spp. on celery (1/6), lettuce (2/4), mung bean sprouts (6/10), watercress (2/11), and yams (1/4) (Thunberg et al., 2002). The association between farmed products, such as produce, is not surprising considering *Listeria* spp. is present in numerous environments, including soil and vegetation. In fact, previous studies have demonstrated the ability of *L. monocytogenes* to grow on cauliflower and lettuce stored between 4°C-5°C and tomatoes held at room temperature (Beuchat, 1995; Berrang et al., 1989; Beuchat et al., 1990; Beuchat and Brackett, 1991). While previous studies have shown *Listeria* spp. to be present in a variety of food products at low prevalence, the presence of *Listeria* spp. in food establishments has been responsible for ~249 recalls in the U.S., U.K., and Ireland, between 2004-2010 (Potter et al., 2012). Furthermore, *L. monocytogenes* related recalls were the most frequent cause of recalls for the dairy, fishery product, and poultry meat product industries between 2004-2010 (Potter et al., 2012). Due to the continuous evolution of RTE food products and the technologies used to harvest and process raw meats and produce, future studies are needed to investigate the prevalence, growth, and survival of *Listeria* spp. in these important categories of foods sold at retail and at direct-to-consumer venues.

**Indicator organisms for safety and quality of food**

**Background**

Shortly after the discovery and identification of *E. coli*, the organism was being used as a type of indicator for the presence of enteric pathogens in water (Mossel et al., 1995). Scientists at the time presumed that because *E. coli* and other enteric pathogens were isolated from feces of
animals and humans, their presence was an indication that other enteric pathogens were likely present (Kornacki et al., 2015). In 1915, the U. S. Public Health Service began testing for coliforms rather than *E. coli* based on the idea that the coliform group was more indicative of fecal contamination in water (Kornacki et al., 2015). Since then, the concept of an indicator bacteria, its application to food and water quality, testing methods, and interpretations of test results, have been controversial, contested, and refuted, yet indicator testing continues to be used today (Kornacki et al., 2015).

Traditionally, the presence of coliforms, fecal coliforms, *E. coli*, and *Enterobacteriaceae* in water, soil, or food was interpreted as being either a source contaminated with feces from animals or humans, or an indication that enteric pathogens were present (Kornacki et al., 2013). However, countless studies have demonstrated that: *E. coli*, coliforms, and other *Enterobacteriaceae* are not obligate residents of the GI tract of animals and humans; many environmental sources of those organisms exist; these organisms can become residents of food manufacturing facilities; and the growth of these organisms has been observed to occur at refrigeration temperatures (Chordash and Insalata, 1978; Kornacki et al., 2015).

Today, it is generally understood that the best use of indicator organisms is in the assessment of the overall quality of food and the hygienic conditions that existed during processing (Kornacki et al., 2015). To remove the ambiguity surrounding the term “indicator,” many researchers and industry members have utilized terms such as “process indicators” and “index” or “model/surrogate organisms” (Odonkor and Ampofo, 2013). A process indicator refers to “a group of organisms that demonstrate the efficacy of a process such as total heterotrophic bacteria or total coliforms for chlorine disinfection” (Odonkor and Ampofo, 2013). An index or model organism refers to “a group/or species of pathogen presence and behavior, respectively, such as *E. coli* as an
index for Salmonella and F-RNA coliphages as models of human enteric viruses” (Odonkor and Ampofo, 2013). In this sense, the use of indicator organisms should be specific, used only to provide estimated results, and scientifically evaluated prior to sampling to ensure the testing is appropriate for the specific situation. For example, the use of fecal coliforms and E. coli are still regarded as appropriate indicators of fecal contamination. However, their presence does not indicate pathogens are present nor remove the possibility that they may originate from an alternative reservoir then feces (Busta et al., 2003). Similarly, the testing for Listeria spp., in a RTE food production facility may be a suitable indicator of sanitation and food quality; however, its presence does not necessarily correlate to the presence of L. monocytogenes.

Coliforms and fecal coliforms

The term coliform is thought to have originated in 1893 by Blachstein and referred to bacilli that resembled E. coli (Kornacki et al., 2015; Blachstein, 1893). The term coliform has no taxonomic status and is based off of biochemical reactions (Kornacki et al., 2015). Coliforms represent more than 20 species of bacteria, and are typically classified as aerobic or facultative anaerobic, Gram-negative, non-sporeforming rods that ferment lactose, and form acid and gas within 48 hours at 35°C. Fecal coliforms are an additional group of coliforms which are classified as coliforms which ferment lactose and produce acid and gas within 48 hours at 44.5°C or 45.5°C. Fecal coliforms can include E. coli, Klebsiella pneumoniae, Enterobacter spp., and Citrobacter freundii (Kornacki et al., 2015). Fecal coliforms also do not have a taxonomic status, and are sometimes referred to as thermotolerant coliforms. E. coli are considered part of the fecal coliform group. However, it is important to note that some E. coli strains do not grow optimally at the elevated temperatures used for fecal coliform testing (44.5°C or 45.5°C). In fact, studies have shown that EHEC strains grow poorly or not at all at 45.5°C (Doyle et al., 1984).
**Testing and interpretation**

Although coliform, fecal coliform, and *E. coli* isolation and testing can be performed independently, if an estimate of concentration is required, the Most Probable Number (MPN) method is typically utilized to enumerate groups of indicator bacteria in a stepwise fashion. The MPN method is a statistical, multi-step assay, which involves performing a series of step-wise enrichments performed in replicates using multiple dilutions (Blodgett, 2010). The completion of the assay also involves confirmation of presumptive *E. coli* cultures through direct plating and subsequent biochemical testing. The use of the MPN method is advantageous when it is expected that the concentration of an indicator organism will be particularly low (<100/g), and less likely to be isolated through direct plating (Blodgett, 2010). The use of the MPN method requires certain assumptions: 1.) the bacteria are distributed randomly within a sample; 2.) the bacteria are separate, not clustered, and do not repel each other; 3.) a positive enrichment tube originates from at least one viable organism; and 4.) the individual enrichment tubes from a sample are independent (Blodgett, 2010).

In general, the MPN method is based on the idea that through subsequent dilutions of a sample, enrichment tubes will not always contain a viable organism, and the number of tubes exhibiting bacterial growth implies an estimate of the original, undiluted concentration of bacteria in the sample (Blodgett, 2010). Through the use of reference MPN tables, which list the calculated bacterial concentrations for each scenario of positive replicate enrichment tubes at different dilutions, an estimated concentration of coliforms, fecal coliforms, and *E. coli* can be determined. The following MPN formula is used to determine the estimated bacterial concentrations following the MPN methodology (FDA, 2015):
\[ \text{MPN/g} = \left( \sum g_j \right) / \left( \sum t_j m_j \sum (t_j - g_j) m_j \right)^{0.5} \]

\( \sum g_j \) denotes the number of positive tubes in the selected dilutions,

\( \sum t_j m_j \) denotes the grams of sample in all tubes in the selected dilutions,

\( \sum (t_j - g_j) m_j \) denotes the grams of sample in all negative tubes in the selected dilutions.

Table 1 provides an example of an MPN table containing bacterial concentrations using the above formula, based on the dilution series and number of enrichment replicates. For example, in a 3-tube MPN, if the number of positive tubes for a dilution series of 0.1, 0.01, and 0.001 g inocula is (3-2-1), the calculated bacterial concentration is reported as 150 MPN/g at a 95% confidence interval, with a possible low concentration of 37 MPN/g and a high of 420 MPN/g (Blodgett, 2010). Increasing the amount of replicates for each dilution of enrichment, increases the statistical power and lowers the confidence intervals for each calculated concentration. Therefore, MPN studies can be performed using 3, 5, and 10 tubes per dilution. However, processing a large number of samples using a 5 and 10 tube-MPN can be extremely time consuming.

<table>
<thead>
<tr>
<th>Positive Tubes</th>
<th>MPN/g</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;3.0</td>
<td>-</td>
<td>9.5</td>
</tr>
<tr>
<td>0</td>
<td>3.0</td>
<td>0.15</td>
<td>9.6</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
<td>0.15</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>6.1</td>
<td>1.2</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>6.2</td>
<td>1.2</td>
<td>18</td>
</tr>
<tr>
<td>0</td>
<td>9.4</td>
<td>3.6</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>93</td>
<td>18</td>
<td>420</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>37</td>
<td>420</td>
</tr>
<tr>
<td>3</td>
<td>210</td>
<td>40</td>
<td>430</td>
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<td>90</td>
<td>1000</td>
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<tr>
<td>3</td>
<td>240</td>
<td>42</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>460</td>
<td>90</td>
<td>2000</td>
</tr>
<tr>
<td>3</td>
<td>1100</td>
<td>180</td>
<td>4100</td>
</tr>
<tr>
<td>3</td>
<td>&gt;1100</td>
<td>420</td>
<td>-</td>
</tr>
</tbody>
</table>
The MPN procedure typically begins by preparing samples of food, water, or other materials using standard methodologies to produce a blended mixture or stomachate, which is then aliquoted into serial dilutions. For a 3-tube MPN, each serial dilution is used to inoculate tubes of a primary enrichment broth containing lactose as the primary carbohydrate source, in triplicate, and incubated at 35°C for 24-48 hours (Blodgett, 2010). Standard methodologies typically utilize lauryl tryptose broth (LTB), as the initial enrichment, which contains sodium lauryl sulfate as an inhibitor of non-coliform bacteria (Anonymous, 2011b). Durham tubes placed upside down within each enrichment tube are used to observe the presence of gas production, and incubated tubes are considered positive if gas is present and the enrichment is turbid. Positive tubes are then used to inoculate an identical series of secondary enrichments to confirm the presence of coliforms, fecal coliforms and E. coli (Blodgett, 2010).

Brilliant green bile broth (BGBB) is typically used for the detection of coliforms, which contains lactose and enzymatic digest of gelatin as carbon and nitrogen sources, while ox bile and brilliant green are present to inhibit Gram-positive and non-coliform bacteria (Anonymous, 2010b). BGBB tubes showing turbidity and gas production are considered positive for coliform growth. E. coli (EC) broth is used to determine the presence of fecal coliforms and E. coli, which contains lactose and casein digest as carbon and nitrogen sources, while bile salts and sodium chloride inhibit Gram-positive and non-coliform bacteria (Anonymous, 2015c). EC broth is incubated at 44.5°C - 50°C for 24-72 hours, and growth and gas production is considered positive for fecal coliforms and presumptive E. coli. Positive EC tubes are typically streak-plated onto Levine’s eosin methylene blue agar (L-EMB), which contains lactose and enzymatic digest of gelatin as nitrogen and carbon sources, and the pH indicators eosin Y and methylene blue, which together, impart a metallic sheen in strong acidic conditions (Anonymous, 2011c). Blue-black
bullseye colonies with or without a green metallic sheen on L-EMB are indicative of *E. coli*, which can be confirmed using IMViC biochemical testing in combination with other confirmatory analyses (serological, PCR, ELISA). Positive EC tubes which resulted in confirmed colonies of *E. coli* can be used to determine the MPN/g concentrations of *E. coli* in the sample.

**Statement of the problem**

The continued success and existence of farmers’ markets in Pennsylvania, and in the U. S. is a primary concern for the Pennsylvania and U. S. agricultural communities, as demonstrated by the rapid increase and sustainment of 297 active farmers’ markets in PA, and over 8,000 in the U. S. Farmers’ markets provide thousands of farmers in Pennsylvania and hundreds of thousands in the U. S. an economic opportunity to sell their agricultural products outside of the conventional commercial markets, while also allowing them control during harvesting, processing, packaging, transportation, and final sale of their products, from farm to fork. Previous research has demonstrated that farmers selling foods at farmers’ markets can lack basic food safety and food processing knowledge and skills, resulting in a loss of product quality and an increase in public food safety risks. Recent studies also have found the presence of pathogens on actual raw and RTE farmers’ market products sampled at retail, while several outbreaks associated from foods sold at farmers’ markets have also occurred in the last decade.

While these incidents have yet to cause mass public illness or capture national media attention, there is a great potential for a single food safety incident to jeopardize the farmers’ market movement, toppling a billion dollar industry, endangering the livelihoods of hundreds of thousands of farmers’ in the U. S., and causing illnesses and potential deaths of consumers. Research has shown that farmers who sell foods at farmers’ markets face many unknown and unforeseen challenges, and may be unaware that they may be engaging in retail and food
production practices which negatively affect the quality and safety of the foods they produce and sell. To maintain consumer confidence, ensure public safety, and for farmers’ markets to remain viable, foods sold at these venues must maintain a high level of quality and safety. Furthermore, for farmers’ market vendors to preserve a newfound customer base and sustain direct-to-consumer businesses, maintaining the quality and safety of the foods they sell is paramount.

To date, several studies have evaluated specific elements of farmers’ market food safety, such as consumer preferences and vendor behaviors. Additionally, training programs for farmers’ market vendors have been developed. However, current available programs may not be focused specifically on food safety, may not be validated scientifically, and content may not be based on actual farmers’ market needs assessments. Furthermore, no current training program has been developed to address the specific and unique needs of Pennsylvanian farmers’ markets and vendors. Research is needed to assess the unique food safety issues related to farmers’ markets and vendors in Pennsylvania, while exploring unknown risks applicable to the entire U. S. farmers’ market industry.

Statement of objectives

The purpose of this study is to perform a comprehensive food safety assessment of farmers’ markets in Pennsylvania, assess microbiological risks of produce and meat sold at farmers’ markets in Pennsylvania, and to utilize those findings to develop and pilot-test a new food safety training program for farmers’ market vendors through the following objectives:

Objective 1: Perform a comprehensive needs assessment of farmers’ market vendors in PA to identify key gaps in food safety related to farmers’ market vendor retail behaviors, vendor food safety knowledge and attitudes, public health inspection deficiencies of vendors, and market manager attitudes and opinions.
**Objective 1.1:** Farmers’ market vendor food safety retail related behaviors will be assessed through concealed observations performed at farmers’ markets in PA using a specially-designed smart-phone application (Food Safe Surveys).

**Objective 1.2:** Farmers’ market vendors’ knowledge and attitudes on food safety-related topics will be assessed through in-person surveys administered at farmers’ markets in PA.

**Objective 1.3:** Pennsylvania Department of Agriculture (PDA) public health inspector’s inspection results and observations of PA farmers’ market vendors, will be assessed through online and in-person surveys to assess common food safety deficiencies identified during farmers’ market vendor public health inspections in PA.

**Objective 1.4:** A focus group of farmers’ market managers in PA will be performed to explore their experiences, ideas, and feelings on food safety training for farmers’ market vendors, and their perceived role in ensuring food safety at farmers’ markets.

**Objective 2:** Perform a microbiological safety and quality assessment of leafy-green produce, beef, and pork, sold at farmers’ markets in Pennsylvania, based on the enumeration, isolation, and molecular characteristics of *E. coli* and *Listeria* spp. found in those food products obtained from farmers’ markets in PA.

**Objective 3:** Based on the results of objectives 1 and 2, identify the key gaps related to food safety at farmers’ markets, and develop a unique and specific food safety training program for farmers’ market vendors in PA.

**Objective 3.1:** Perform a pilot-test and validation of the developed food safety training program for farmers’ market vendors in PA.
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Chapter 2

A comprehensive needs assessment of retail food safety practices of farmers’ market vendors in Pennsylvania
Abstract

Since the colonial era, farmers in the U. S. have utilized a constantly changing system of markets to barter, sell, and distribute their farmed goods to the local populace. Today, farmers’ markets have replaced old-world style markets with over 8,000 farmers’ markets operating in the U. S. currently. As farmers’ markets have increased in size, scope, and complexity in the kinds of foods sold at these venues, so has the potential food safety risks. Previous observational and survey research of farmers’ markets in various regions of North America have revealed that in many cases, farmers’ market vendors can lack important knowledge and experience in food safety practices and behaviors. These studies have observed vendors performing high-risk retail food safety behaviors. Throughout the past decade, numerous outbreaks and recalls associated with farmers’ market sold food products also have been reported, further highlighting the food safety implications of farmers’ markets. While these incidents have yet to cause mass public illness or capture national media attention, there is a great potential for a food safety incident to jeopardize the farmers’ market movement. More robust and comprehensive studies are needed to evaluate the food safety implications of farmers’ markets in the U.S., using multiple tools and focusing on multiple areas of food safety risks. Therefore, the purpose of this study is to perform a comprehensive food safety needs assessment of farmers’ markets in Pennsylvania through the use of direct concealed observations, vendor surveys, state health inspector surveys, and structured group interviews with market managers.

The results of this study revealed important gaps in vendor retail food safety behaviors, knowledge, and attitudes. Specifically, vendors were found to demonstrate sufficient knowledge in certain food safety topics such as hand washing, personal hygiene, and cross-contamination; however, this knowledge was not translated into proper food safety behaviors at farmers’
markets. Observations of vendor-related retail food safety behaviors and state health inspector-reported inspection outcomes coincided, while many vendor self-reported behaviors were counter to those behaviors observed by the researchers. Opinions, interpretations, and ideas offered from interviewed farmers’ marker managers also provided additional insight into why vendors may have knowledge in certain areas which may not be translated into good retail practices. Based on these outcomes, it has been concluded that farmers’ market vendors in PA would greatly benefit from a customized food safety training program which addresses the needs and gaps determined in this study.
Introduction

Since the colonial era, farmers in the U.S. have utilized a constantly varying system of markets to barter, sell, and distribute their farmed goods to the local populace. Presently, the USDA has defined a farmers’ market as, “a multi-stall market at which farmer-producers sell agricultural products directly to the general public at a central or fixed location, particularly fresh fruit and vegetables (but also meat products, dairy products, and/or grains)” (USDA, 2015a). While the number of farmers’ markets remained relatively low between the 1970s and early 1990s, the past two decades have witnessed extraordinary growth in the U.S., with over 8,200 farmers’ markets in operation in 2014 (USDA, 2015b). As the number of farmers’ markets have grown, so has the diversity and complexity of foods sold at farmers’ markets (USDA, 2015b).

Today, the USDA Agricultural Marketing Service (AMS), National Farmers’ Market Directory lists 28 categories of food products, which vendors have reported selling at their respective markets (USDA, 2015b). Among farmers’ markets listed through the USDA-AMS directory in 2015, 36% (3,101 markets) are selling prepared foods, 60% (5,061 markets) meat or poultry, and 15% (1,254) fish or seafood (USDA, 2015b). Although fresh produce continues to remain the dominant product sold at farmers’ markets, Time and Temperature Control for Safety (TCS) foods, formerly known as Potentially Hazardous Foods (PHF) such as meat and seafood, and Ready-to-Eat (RTE) prepared foods, are much more common at farmers’ markets then they ever have been in history (USDA, 2015b; FDA, 2014). These changes in the kinds of foods sold at farmers’ markets and increase in markets selling TCS and RTE foods are not only socially significant, but also present new food safety challenges and implications. As a result, several studies have begun to explore food safety risks at farmers’ markets and have identified high-risk food safety factors unique to farmers’ markets and farmers’ market vendors.
In 2004, researchers in Ontario, Canada observed 17 farmers’ market cheese vendors and reported 47% were not properly refrigerating cheese, 88% did not wash their hands before or after handling cheese, and 24% stored cheese next to raw foods, such as meat (Teng et al., 2004). A knowledge, attitudes, and behavior survey performed in Pennsylvania among 21 farmers’ market poultry vendors revealed that 43% did not use any sanitizers or antimicrobials during their poultry processing operations, only 24% used chemical sanitizers to clean their processing areas, 33% were found to be processing outside, and over half of vendors had their chickens slaughtered and processed by a third party, with little to no knowledge of the processing conditions (Scheinberg et al., 2013b). In a similar study, McIntyre et al. (2014) surveyed 107 farmers’ market vendors in British Columbia, Canada on food safety related behaviors and knowledge and found that: 34% of farmers’ market vendors were unable to identify PHF among a list of common foods and 29% were unable to identify proper methods of reducing the temperature of PHF (Mcintyre et al., 2014). In addition to survey and observational studies, microbiological assessments of farmers’ market products have revealed compelling results.

In 2009, researchers sampled produce (n=600) from Canadian farmers’ markets and reported 18% of lettuce (n=128), 27% of spinach (n=59), and 5% of green onion (n=129) samples were positive for E. coli, with an additional spinach sample positive for Cryptosporidium (Bohaychuk et al., 2009). A comparative study on farmers’ market and supermarket-purchased, raw, whole chicken by Scheinberg et al. (2013a), identified that 28% and 90% of whole chicken purchased from farmers’ markets (n=100) in PA were positive for Salmonella spp. and Campylobacter spp., respectively, compared to 8% and 52% of poultry purchased at supermarkets (n=100) positive for the same pathogens. Most recently, among vegetables (n=242) sampled at 21 Asian farmers’ market vendors in Northern California, 100%
were found to be positive for fecal coliforms, 20% positive for *E. coli* and 7% positive for *Salmonella* serovars Newport, Enteritidis, Agona, and Worthington, among samples of basil (n=23), okra (n=43), radlong beans (n=72), squash (n=89), and cilantro (n=15) (Pan et al., 2015).

Unfortunately, the kinds of microbiological hazards identified in foods sampled from farmers’ markets in previous studies, also have caused several documented foodborne outbreaks from foods sold at North American farmers’ markets. Since 2008, seven major foodborne outbreaks and two recalls have been attributed to foods sold at farmers’ markets, causing 80 known reported illnesses, the kidney failure of a 4 year old girl, and 1 death (Gardner et al., 2011; Anonymous, 2010; Goetz, 2011; Anonymous, 2012; Anonymous, 2013; Anonymous, 2007; Holton, 2014; Siegner, 2015). Pathogens found to be the cause of these outbreaks have included: *Campylobacter*, *E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes*. Food contaminated with these pathogens have included: raw bagged peas, fresh strawberries, raw milk, various cheeses, RTE Mexican dishes, and unpasteurized apple cider (Gardner et al., 2011; Anonymous, 2010; Goetz, 2011; Anonymous, 2012; Anonymous, 2013; Anonymous, 2007; Holton, 2014; Siegner, 2015).

Historically, farmers selling food products at farmers’ markets in most U.S. states were exempt from the regulations and policies of food safety and sanitation which applied to retail-type food establishments. However, due to the rapid increase in number of farmers’ markets and the collective realization of the risks associated with direct-to-consumer marketing, many states have moved from traditional cottage food laws to more modern food safety regulations, specifically targeting farmers’ markets. In fact, between 2010 and 2011, 8 states have passed specific state legislation addressing farmers’ markets in the areas of food safety, food fraud,
licensing, and establishing rules for the kinds of foods allowed to be produced for sale at farmers’ markets (O’Brien, 2011).

While the reported outbreak incidents and research revealing food safety risks at farmers’ markets have yet to cause mass public illness or capture national media attention, there is great potential for a single food safety incident to jeopardize the farmers’ market movement, toppling a billion dollar industry, endangering the livelihoods of hundreds of thousands of farmers’ in the U.S., and causing the sickness and potential death of consumers. More robust and comprehensive studies are needed to evaluate the food safety implications of farmers’ markets in the U.S., focusing on multiple facets of the farmers’ market dynamic. Furthermore, research is needed to determine whether food safety risks may vary by state and by the types of foods sold. Therefore, the purpose of this study is to perform a comprehensive food safety needs assessment of farmers’ markets in Pennsylvania through the use of direct concealed observations, vendor surveys, state health inspector surveys, and structured group interviews with market managers.

Objectives

Objective 1: Perform a comprehensive needs assessment of farmers’ market vendors in PA to identify key gaps in food safety related to farmers’ market vendor retail behaviors, vendor food safety knowledge and attitudes, public health inspection deficiencies of vendors, and market manager attitudes and opinions.

Objective 1.1: Farmers’ market vendor food safety retail related behaviors will be assessed through concealed observations performed at farmers’ markets in PA using a specially-designed smart-phone application (Food Safe Surveys).
Objective 1.2: Farmers’ market vendors’ knowledge and attitudes on food safety-related topics will be assessed through in-person surveys administered at farmers’ markets in PA.

Objective 1.3: Pennsylvania Department of Agriculture (PDA) public health inspector’s inspection results and observations of PA farmers’ market vendors, will be assessed through online and in-person surveys to assess common food safety deficiencies identified during farmers’ market vendor public health inspections in PA.

Objective 1.4: A focus group of farmers’ market managers in PA will be performed to explore their experiences, ideas, and feelings on food safety training for farmers’ market vendors, and their perceived role in ensuring food safety at farmers’ markets.

Methodological Diagram
Methods

Direct concealed observations of retail food safety practices of farmers’ markets vendors in PA

IRB approval for direct concealed observations and the Pennsylvania Department of Agriculture (PDA) public health inspector needs assessment survey

This portion of the study involved the use of human subjects and their unknowing participation in a confidential, direct concealed observational assessment or an in-person survey. Due to the use of human subjects and the sensitivity of performing concealed observations and surveying public health officials, approval from the Pennsylvania State Universities’ Institutional Review Board (IRB) was necessary to perform this research. Through the PSU-IRB online system, the proposed methods and materials of the direct concealed observational assessment and PDA health inspector needs assessment survey were submitted to the IRB through the Office of Research Protections at The Pennsylvania State University. It was determined that the observational assessment and survey were considered expedited and were approved on 11/4/2014, PRAMS00044749. IRB approval was granted to perform direct concealed observations at Pennsylvania farmers’ markets without needing permissions or providing notifications to vendors or farmers’ market managers. PDA health inspectors were permitted to be recruited for surveys after being notified through their supervisory leadership. For both the observational assessment and survey, names and identities of participants were to remain confidential and only known to the approved researchers and principal investigator of this study. Participant identities would never be associated with any of the collected observations or survey responses, and collected data would be kept secure in password-protected documents and locked cabinets and offices.
Identification of farmers’ market vendors in Pennsylvania

Due to the grassroots and local nature of many farmers’ markets, detailed descriptions of farmers’ markets and their associated market managers, vendors, hours of operation, locations, and products offered are not always available or updated via the internet. Therefore, this study utilized multiple sources to identify farmers’ markets throughout Pennsylvania. Farmers’ markets were identified using multiple web sites, advertisements, brochures, and word-of-mouth. Online internet sources included the Buy Fresh, Buy Local (http://www.buylocalpa.org/), Local Harvest (www.localharvest.com), and the USDA-AMS National Farmers’ Market Directory (http://www.ams.usda.gov/local-food-directories/farmersmarkets).

For the direct concealed observational assessment, a convenience sample of 42 farmers’ market vendors in 8 farmers’ markets were selected to be observed through direct concealed observation methods. Farmers’ markets chosen for the study were selected based on their geographic location, number of vendors present, and number of food types sold. Selected farmers’ markets were located in the western, central, and eastern parts of Pennsylvania, in major city centers, however the exact locations will remain confidential due to IRB requirements. Farmers’ markets chosen for this study were located in areas where farmers’ markets were most prevalent, and in densely populated regions of Pennsylvania. Vendors selected for direct concealed observations were chosen based on the types of foods they produced and sold, in an effort to select vendors at each farmers’ market which sold different types of foods. Vendors selected sold raw foods, RTE foods, RTE prepared foods, and TCS foods (Figure 1). Between 5-6 farmers’ market vendors were selected to be observed at each farmers’ market based on the time and resources available to the researcher.
Tools used to conduct direct concealed observations

In this study, direct concealed observations of farmers’ market vendors were performed using an innovative smart-phone application, developed at the Pennsylvania State University, called “Food Safe Surveys”. This application has been pilot-tested and described in detail in Machado et al. (2015). In short, the “Food Safe Surveys” smart-phone application was specifically designed for observational research, whereby the researchers using the application can rapidly record observational data using a customized survey-type interface on a smart-phone. Machado et al. (2015) demonstrated that the use of a phone in a retail-food environment is not perceived by the public as inspection or survey-like behavior, as compared to the use of a clipboard with pen and paper. Therefore, “Food Safe Surveys” was selected for its use in this study, to allow for the recording of concealed observations with a low probability of the observed vendors being aware of the observational research and thus, avoiding unintended changes in vendor behavior (e. g., Hawthorne Effect (Machado et al., 2015)).

Preparation of direct concealed observational tools

Using the secure “Food Safe Surveys” web-based survey development tool, a customized question route was developed, which included 20 farmers’ market-specific questions and 26 vendor-specific questions. However, certain questions may not have applied to every farmers’ market or vendor (Appendix A). Market-specific questions were designed to assess the general environment of the farmers’ market, the presence of food safety materials and hand washing access, and the types of foods sold at farmers’ markets. Vendor-specific questions were focused on identifying retail vending conditions, high-risk, food safety related behaviors, and product-specific risk factors. Questions were formatted to be answered objectively with either yes/no, multiple choice, or free-text responses (Appendix A). Both the market-specific and vendor-
specific question routes (Appendix A) were critiqued by faculty and staff in the Department of Food Science at Penn State to assess the validity and effectiveness of the proposed observational assessment. A reliability assessment was not performed on this tool, since one researcher performed all of the observations, all of the observational questions and possible responses were objective-based and factual, and the reliability of “Food Safe Surveys” was previously assessed in Machado et al. (2015). Once finalized, the question route was downloaded to an android-based smart-phone, pre-tested for accuracy and functionality, and used for the remainder of the study. Collected responses were stored within the smartphone, transferred to a password-protected computer, and the data transferred to a password-protected computer file. Smartphone data was deleted following the computer transfer, and no pictures or video were taken of observed vendors.

Direct concealed observations of farmers’ market vendors

Direct concealed observations were performed on-site at each respective farmers’ market identified in the study. The same researcher performed each observation and traveled to each farmers’ market on the selected market day, or one day prior for longer distance trips. Observations were performed periodically between January and August 2014 to account for potential seasonal differences, in an attempt to observe each vendor multiple times (Table 1). However, the absence of selected vendors at selected farmers’ markets on the chosen observations days resulted in some vendors being observed only once or twice. Overall, 25 vendors were observed 3 times; 11 were observed 2 times, and 6 vendors were observed 1 time, for a total of 22 separate farmers’ market visits, with 102 observations performed (Table 1).

During each observation period, an initial walk-through of the farmers’ market was performed to identify locations of each vendor, vantage points to observe vendor behaviors, and
to collect market specific information. Each vendor was observed for a duration of approximately 20-30 minutes by standing or sitting out of view of targeted vendors, while answering vendor specific questions on the “Food Safe Surveys” application. In some cases, certain vantage points allowed for observations of multiple vendors at the same time. Repeat visits to farmers’ markets were performed to identify whether observed vendor behaviors might be sporadic, repeated, or possibly performed due to conditions unique to the selected day of observation. Repeated visits to farmers’ markets were performed approximately one month apart to reduce the chances of vendors noticing the repeated presence of the researcher, and to account for sporadic conditions at a farmers’ market, which may not be indicative of normal operations. Based on the approved IRB methods, no vendor or market manager was notified of the study, and in no case did it appear that vendors or market managers were aware of the ongoing observational assessment.

Farmers’ market vendor retail food safety needs assessment survey

IRB approval for the farmers’ market vendor retail food safety needs assessment survey

This portion of the study involved the use of human subjects and their participation via an in-person survey, and therefore, IRB approval was sought prior to conducting the needs assessment survey. As previously described, the proposed needs assessment survey methods and materials were submitted to the IRB through the Office of Research Protections at The Pennsylvania State University. It was determined on May 6, 2015, that the needs assessment survey (STUDY00002587) was considered exempt from requiring IRB review and approval. However, to keep consistency between the other portions of the overall needs assessment study, farmers’ markets and vendor identities of those surveyed remained confidential and only known to the approved researchers and principal investigator of this study. In addition, vendor identities
would not be associated with any of the survey responses, and collected data would be kept secure in password-protected computer files and in locked cabinets and offices.

*Development of the farmers’ market vendor retail food safety needs assessment survey*

The results gathered from the direct concealed observational assessment identified actual retail-related vendor behaviors at the farmers’ market. To further assess gaps in retail food safety practices at farmers’ markets, based on applicable Food Code and PDA retail food safety regulations, the purpose of the farmers’ market vendor retail food safety needs assessment survey was to collect self-reported behaviors from vendors and assess their knowledge and attitudes on topics related to retail food safety. Based on the results of the direct concealed observational assessment, a paper-based survey was developed to further explore key gaps identified by vendor observations. The survey consisted of 4 sections (38 questions) including: self-reported market behaviors (14 questions), retail food safety knowledge (8 questions), retail food safety attitudes (8 questions), and training preferences and demographic (8 questions) (Appendix B). All questions were formatted as multiple choice, except the attitudinal questions, which were formatted using a five-point Likert scale. The paper-based survey was printed on standard 8.5” x 11” paper using a font size of 12, and questions were printed on both the front and back of the paper (Appendix B). Before implementation of the survey, draft surveys and survey questions were reviewed by professors in the Department of Food Science at Penn State, graduate students, and multiple lay persons outside of the food science field in order to assess the overall validity, which included: readability of questions, length of time of completion, whether questions were understandable, and identification of grammatical errors. The final, 38-question survey was estimated to take vendors 15-20 minutes to complete. Due to time constraints and the scale of this portion of the overall needs assessment study, a pilot study was not performed prior to
survey implementation; however surveyed vendors did not show difficulty in reading or taking the survey. In addition, a post-hoc reliability assessment using Cronbach’s alpha (Santos, 1999) was performed on the attitudinal assessment portion of the needs assessment survey which revealed a value of 0.95.

Conducting the farmers’ market vendor retail food safety needs assessment survey

Two farmers’ markets and one community-organized farmers’ market vendor outreach program was targeted for conducting the needs assessment survey, based on established available contacts with farmers’ market managers and community leaders. Farmers’ markets and vendors selected for the survey were therefore, considered a convenience sample; however, they were located in either the western, eastern, or central part of Pennsylvania to account for regional differences. Approval was gained from each respective farmers’ market manager or community leader to conduct the vendor surveys at the farmers’ market or community event. Market manager and community leader contacts were asked to notify their vendors to expect a researcher to approach them during market hours or at the community event, and vendors were notified they would receive $10 for their participation. On the scheduled survey day, the researcher would travel to each respective farmers’ market or community event and meet with their contact at the farmers’ market or event prior to conducting the survey. Vendors were individually approached at the market or event and asked to participate in the survey using a pre-formatted and memorized verbal script (Appendix B). Once vendors agreed to participate, vendors were read the informed consent form (Appendix B), and only once vendors verbally agreed and signed the consent form, were they allowed to participate in the survey. Vendors were informed that their answers to questions were completely confidential and never associated with their contact information. Vendors also were informed that they could stop the survey at any time and could
skip questions. Paper surveys were handed physically to each vendor and the researcher would leave the area. Typically, vendors spent between 15-30 minutes to complete each survey. Once completed, the researcher would answer any questions, and upon receiving the completed survey, vendors were awarded $10 cash. Vendors were not given the option to complete the survey at a later date; however no vendors made this request. Among the approximately 70 vendors made available for their participation in the survey, 55% (39/70) completed the survey, which was considered suitable based on the time restraints and allotted funds available for vendor incentives. Responses to questions were transferred to password-protected computer files and no identifying information was ever associated with survey responses.

PDA public health inspector needs assessment survey

Development of the PDA health inspector needs assessment survey

Based on the current regulations in Pennsylvania and depending on the types of foods sold, individual farmers’ market vendors must be inspected by PDA or local public health inspectors annually. Since 2011, PDA public health inspectors have performed hundreds of inspections on farmers’ market vendors in Pennsylvania (private communications). The purpose of this portion of the overall needs assessment study was to collect the observations made by PDA public health inspectors during their inspections and determine the conditions which led to inspection outcomes. Through the use of the PDA Food Establishment Inspection Report (Appendix D), a paper-based and identical web-based survey were developed. The survey consisted of two sections (35 questions): general farmers’ market inspection questions (3 questions) and results of past inspections of farmers’ market vendors questions (32 questions) (Appendix C). The initial three questions were formatted as multiple choice and were used to determine the number of vendors inspected by PDA health inspectors and types of food products
observed being sold during inspections. The second section utilized 16 actual inspection items taken from the PDA Food Establishment Inspection Report, which were framed into questions asking inspectors how often those items were observed to be out of compliance during inspections.

The first section of each compliance item question were formatted using a six-point Likert scale which were each proceeded by an additional multiple choice follow-up question, asking inspectors to select common reasons for the non-compliance. The paper-based version of the survey was printed on standard “8.5 x 11” paper using a font size of 12 and questions were printed on both the front and back of the paper. An identical web-based version of the survey was developed and made available online through RedCap (Research Electronic Data Capture) software (Harris et al., 2009). Both the paper-based and web-based surveys also included an initial qualifier question to prevent inspectors who had never inspected a farmers’ market from participating in the survey (Appendix C). Before implementation of the survey, draft surveys and survey questions were critiqued by professors in the Department of Food Science at Penn State, and sent to collaborating PDA administrators to assess validity and receive PDA approval. The final, 35-question survey was estimated to take inspectors 15-20 minutes to complete. Due to the unique nature of the audience being surveyed and limited access to conduct surveys of PDA public health inspectors, a pilot study was not performed prior to survey implementation.

Conducting the PDA public health inspector needs assessment survey

Following the development of the survey and approval from collaborating PDA administration, a link to the web-based survey and a survey code was provided to the collaborating PDA official, who then disseminated the survey link to PDA public health inspectors. Since the web-based version was posted publicly, a survey code option through
RedCap was used to prevent non-PDA public health inspectors from gaining access to the survey. The web-based survey also included an informed consent page, prior to allowing access to the survey, in addition to the initial screener question. Only inspectors who agreed to the conditions of the informed consent through pushing the “next” button on the survey screen and those who selected “yes” to having inspected farmers’ markets were allowed access to the survey.

Completed web-based surveys were monitored through RedCap, and the survey was kept online for 3 months. Fortunately, an opportune training program for PDA public health inspectors occurred at Penn State shortly following the implementation of the web-based survey. Prior to this training program, approval was received from PDA officials to conduct a paper-based version of the survey during the break times of the training program. During this training program, an announcement was made to inform inspectors that surveys would be disseminated, and researchers approached each inspector to request their participation and complete the survey. Consent forms were provided to each participating inspector and only those who read and signed the consent form were provided the survey. Through the use of web-based and paper-based in-person surveys, 52% (47/90) of PDA public health inspectors consented and completed the survey. No follow-up reminders were used for the web-based version of this survey due to restrictions dictated by the PDA. Responses to questions were transferred to a password-protected computer database and no identifying information was ever associated with survey responses.
Farmers’ market manager structured group interviews

IRB approval for farmers’ market manager structured group interviews

This portion of the study involved the use of human subjects and their participation in a structured group interview, and therefore IRB approval was sought prior to conducting the needs assessment survey. As previously described, the proposed farmers’ market manager structured group interview methods and materials were submitted to the IRB through the Office of Research Protections at The Pennsylvania State University. It was determined on October 22, 2014, that the structured group interview (STUDY00001296) was considered exempt from requiring IRB review and approval. However, to keep consistency between the other portions of the overall needs assessment study, farmers’ market manager identities of those participating in the structured group interview remained confidential and only known to the approved researchers and principle investigator of this study. In addition, market manager identities would not be associated with any of the interview responses, and collected data would be kept secure in password-protected computer files and in locked cabinets and offices.

Development of the farmers’ market manager structured group interview

The purpose of this portion of the overall needs assessment was to seek out the opinions, ideas, and feelings of farmers’ market managers on topics related to farmers’ market food safety and future vendor training in food safety. In addition, market manager interpretations of results gathered from previous portions of the overall needs assessment study were explored. Following the guidelines of Krueger and Casey, (2009), a single-category design was chosen as the format for the structured group interview which would include only farmers’ market manager participants. A 10-question structured group interview question route was developed, which included opening, introductory, transition, key, and ending questions (Kruger and Casey, 2009)
(Appendix E). The question route was reviewed and critiqued by professors in the Penn State College of Agricultural Sciences with experience in focus groups and structured group interviews, and the final questions were tested on graduate students for further critique.

Using the results obtained from the previous portions of the overall needs assessment, three key questions were developed which described study results which were similar among observed vendor retail behaviors and PDA inspector inspection outcomes, but differed from vendor self-reported behaviors (Appendix E). These questions were designed to elicit market manager reactions and interpretations of the presented results, and gain a separate perspective on the topics which may have not been previously explored. The remaining key questions presented to the market manager group were focused on their perspectives of food safety issues at farmers’ markets, and whether they felt they should play a role in ensuring food safety at their markets (Appendix E). The structured group interview was designed to take approximately 1 hour to complete, and included potential follow up questions in case responses to certain questions were minimal.

_Conducting the farmers’ market manager structured group interview_

Through established contacts with farmers’ market managers and Pennsylvania Cooperative Extension educators, market managers were recruited through email and person-to-person contacts. Market managers were sent a pre-formatted recruitment letter (Appendix E) which explained the details of the study and the $20 incentive provided to participants. In total, 10 market managers responded to the structured group interview sessions; however, only eight market managers arrived and participated. The structured group interview session was conducted in a conference room located in the Lehigh County Agricultural Center in Allentown, PA. Prior to the start of the session, participants were read and provided a consent form
(Appendix E), which outlined the parameters of the study, the participant’s confidential participation in the study, and notified participants that the group interview would be recorded. The group interview session began once all eight participants had signed the consent form. The start of the group interview session began with introductions, and then followed the prescribed question route (Appendix E). Participants were encouraged to participate in the discussion and discuss issues which may not be part of the pre-planned question route. Discussions on a single question or topic were allowed to resume until the group interviewer determine they had reached saturation, at which time, the group interviewer would move forward in the question route. The group interview session took approximately 1 hour to complete, and audio recordings were transcribed for further analysis. Due to time and funding restraints, a second group interview session was not performed. However, the results of the single session was determined to be sufficient for the needs and scope of the overall needs assessment study. Transcribed responses were analyzed through a qualitative approach by organizing responses to each question into common themes.

**Statistical analysis**

Observational data, vendor survey responses, and PDA inspector survey responses were compiled and analyzed by converting response rates to percentages. Comparison of measures of central tendency also were calculated for certain questions. Pearson’s Chi-Square and Cramer’s V tests ($\alpha=0.05$) also were used to determine associations between certain observational results, and Cronbach’s alpha tests were used to test for reliability. All statistical testing was carried out using SPSS; IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.
Results

Results from the direct concealed observational assessment, vendor retail food safety needs assessment, and PDA public health inspector needs assessment were organized by topic to triangulate data analysis and determine whether similarities or differences existed between each assessment (Table 21). Market manager opinions, ideas, and statements were used to aid in the interpretation of the needs assessment results, and assist in the further development of farmer’s market vendor food safety educational programming.

Direct concealed observational analysis general characteristics and demographics

Between the months of January to August 2015, a total of 102 individual direct concealed vendor observations were performed on 42 farmers’ market vendors using the Food Safe Surveys smart-phone application (Table 1; Machado et al., 2015). Observed vendors were located in a total of eight farmers’ markets located in major regions and city centers in PA. Among the eight farmers’ markets, (75%; 6/8) were located indoors, (13%; 1/8) were housed in a church, (63%; 5/8) operated in a large barn-like or warehouse structure, and (25%; 2/8) were located in downtown city areas. Eighty-six percent (86%; 36/42) of targeted vendors were observed at least twice, with 60% (25/42) observed in three separate sessions. Between 10 and 26 individual observations or data points were recorded for each vendor during a single observation session, following the pre-determined question routes (Appendix A), resulting in a total of 1,020 to 2,652 total observations recorded. Observed vendors produced and sold a variety of food products, which included a total of 12 product categories (Figure 1). The majority of vendors sold fresh produce, approximately half sold one type of TCS or RTE food, and two vendors sold fresh breads, apple cider, and mushrooms. No demographic data were collected for observed vendors.
Of the 70 vendors selected for recruitment for the retail food safety needs assessment survey, 56% (39/70) participated and completed the survey. Within the group of participating vendors, 20 categories of food products were reported being sold by those vendors which included RTE, TCS, and prepared foods (Figure 22). The top food items sold by surveyed vendors were fruits, vegetables, baked goods, meats, and dairy products. Approximately 66% (25/38) of surveyed vendors also reported that they were inspected by a public health inspector, while 34% (13/38) did not know or had not been inspected previously (Figure 29). Surveyed vendor ages ranged from 18 to 65 years old, with the largest age groups consisting of 22 to 34 year olds (33%; 13/39) and 55 to 64 year olds (28%; 11/39) (Figure 39). Degree attainment from surveyed vendors varied widely, with 53% (21/39) having achieved a bachelor’s degree or higher and 33% (13/39) having attained a high-school diploma or 1 or less years of college education (Figure 39).

PDA public health inspector needs assessment survey general characteristics and demographics

PDA public health inspectors who participated in the survey (52%; 47/90) reported that they had inspected a wide range of farmers’ market vendors in the past three years (Table 11). Approximately one-half of the surveyed inspectors reported inspecting > 31 vendors, with 25% (11/44) having inspected more than 70 vendors. Seventy-one percent (71%; 31/44) of PDA inspectors reported that the vendors they inspected sold all of the listed major food categories (Appendix C), which included: pre-packaged, non-potentially hazardous foods, pre-packaged potentially hazardous foods, RTE on the premises foods, and other non-identified foods (Table 12). PDA inspectors also reported that inspected vendors sold over 18 types of food products,
with a high percentage of TCS and RTE foods (Table 13). No demographic information was collected from PDA public health inspectors.

Vendor hygiene and condition of vending surfaces

During vendor observations, a majority of observed vendors were found to be wearing clean clothing (86%; 88/102) (Figure 3); however, only 24% (24/102) used any kind of hair covering while handling food products at the farmers’ market (Figure 4). Similarly, 67% (29/43) of PDA inspectors reported that personal cleanliness was not typically a compliance issue during inspections (Figure 64). Eighty-two percent (82%; 32/39) of the inspectors reported that when personal cleanliness was out of compliance, it was mainly due to dirty clothing or exhibiting poor hygienic practices (Figure 65).

Observations of vending surfaces revealed that approximately one-half of the vendors used wood vending surfaces, with the remainder of vendors used plastic, metal, or a combination of metal and plastic (Figure 2). Approximately 89% (91/102) of those surfaces were observed to be clean and or covered with a clean covering, with a small percentage (11%; 11/102) found to be soiled or dirty during market hours (Figure 2). Fifty-six percent (56%; 24/43) of PDA inspectors reported that proper food and food contact surfaces used by vendors were “rarely” or “almost never” a compliance issue, with the remainder reporting the inspection item was “sometimes-almost always” in non-compliance (Figure 70). The most common reason for the non-compliance was due to vending surfaces being made of un-cleanable materials, such as wood, which was not covered with a clean cloth or disposable covering (Figure 71).

Additionally, 32% (14/44) of inspectors reported that food contact surfaces were not cleaned or sanitized “often – almost always,” while 38% (17/44) reported the inspection item was “sometimes” out of compliance (Figure 54). The most common reasons for the deficiencies
were due to utensils, cooking tools, or other food contact surfaces not being properly cleaned or sanitized (75%; 30/40), or vendors were unaware of the requirement to properly clean or sanitize food contact surfaces (68%; 27/40) (Figure 55). Alternatively, less than 8% (3/36) of surveyed vendors reported that they do not or don’t know if they clean their vending stand, while a majority (63%; 23/36) stated they cover their vending stand with a clean cloth or disposable covering (Figure 28). Among surveyed vendors who reported cleaning their vending areas, 27% (10/36) use sanitizing wipes, 25% (9/36) use soap and water, and 19% (7/36) use chlorine/bleach (Figure 28).

**Disposable glove use**

Disposable glove use at the farmers’ market among observed vendors was found to be minimal. Only 24% (24/102) of the observations indicated that disposable gloves were present at the vending stand, regardless of their use (Figure 5). Likewise, 34% (13/38) of surveyed vendors reported using disposable gloves at the farmers’ market (Figure 31). Observations occurring during the winter months also revealed that some vendors were using winter gloves to handle foods, which were not made of material that could be cleaned or sanitized easily (Figure 5). Among observations of vendors using disposable gloves to handle food, 43% (10/23) revealed improper glove use behaviors (Figure 6). The most common improper glove use behavior observed was handling money with gloves, then handling unpackaged foods without changing gloves (22%; 5/23). Similarly, 32% (14/44) of PDA inspectors reported that non-compliance for the inspection item “glove used properly” occurred “often-almost always” and 39% (17/44) reported “sometimes” (Figure 68). Furthermore, 74% (31/42) of inspectors found the handling of money to be the most common reason for the non-compliance (Figure 69), with touching the
face or body (62%; 26/42) and touching raw, then RTE foods, without changing gloves (50%; 21/42), being other top non-compliance behaviors.

On a related topic, 33% (14/43) of PDA inspectors reported that the inspection item, “no bare hand contact with RTE foods” was in non-compliance “often-almost always” and (49%; 21/43) “sometimes” (Figure 46). Over one-half of PDA inspectors (61%; 25/41) stated that this non-compliance was due to vendors having disposable gloves available, but not using them, and 58% (24/41) of the inspectors reported that vendors performed bare hand contact with RTE foods with no use of gloves or proper hand washing (Figure 47). When surveyed, vendors were asked how they avoid bare hand contact with foods, and over one-half (55%; 16/29) stated that the foods they sell are pre-packaged, while 24% (7/29) reported the use of tongs or utensils to handle raw foods, and 14% (4/29) use plastic bags to grab foods (Figure 32).

High-risk food handling behaviors and hand washing habits

Hand washing habits of observed vendors varied, depending on the conditions of the farmers’ market, the presence of a hand washing station, and the types of food products sold. It is important to note that in Pennsylvania, farmers’ market vendors are required to use a hand washing station if they are preparing food samples or selling RTE and certain unpackaged TCS foods, such as raw meats. However, it is expected that the handling of any unpackaged food be performed with clean and sanitized hands or with proper glove use, regardless of the type of food product. Since it was not always clear whether certain foods may have been considered RTE or TCS foods (i.e. washed produce), observations of a “lack of hand washing” or “improper food handling” reflected the handling of any unpackaged food product.

Over the course of the observations, few instances of hand washing were observed, whether it was required or not (Figure 9). Hand washing was considered to be required during
58% (59/102) of observations; however, only 8% (5/59) of those observations involved vendors performing proper hand washing when considered “required.” Among instances where hand washing was considered required and not performed, 80% (47/59) were due to handling money with bare hands, then handling unpackaged foods without washing hands, or using some sort of barrier to handle unpackaged foods (Figure 7). Other improper behaviors that were performed by the vendors included touching the body/face then unpackaged food (4%; 2/59), eating then touching unpackaged food (2%; 4/59), coughing or sneezing then touching unpackaged food (2%; 1/59), and handling raw foods then RTE foods without washing hands in between (4%; 2/59); however, these latter behaviors were less common. Non-compliance for the inspection item “proper eating, tasting, drinking, or tobacco use” also was reported by the inspectors to be less common, with 62% (26/42) of inspectors finding the inspection item in non-compliance “rarely-almost never” (Figure 40). When non-compliance occurred, it was primarily due to vendors eating, tasting, or drinking while handling and preparing foods at the market (Figure 41).

Inadequate or lack of hand washing facilities also were reported by PDA inspectors, with 21% (9/43) stating that adequate hand washing facilities were not supplied or accessible “often-almost always” and 45% (22/43) “sometimes” during inspections (Figure 48). The top reasons for the non-compliance reported by inspectors were that farmers markets either do not provide proper hand washing stations for vendors or vendors are unaware of the requirements for a hand washing station (Figure 49). Furthermore 39% (16/41) of PDA inspectors also reported that vendors hands were not clean or properly washed “often-almost always” and 36% (15/41) “sometimes” (Figure 44). The majority of inspectors (93%; 37/40) cited the lack of available hand washing stations or the use of hand-sanitizer, in place of hand washing, as the most
common reasons for the non-compliance (Figure 45). Ninety-six percent (96%; 98/102) of vendor observations also found hand sanitizer to be present in observed vending areas (Figure 8).

When surveyed vendors were asked to describe their hand washing stations, (31% 11/35) many reported that they do provide their own hand washing station and a large portion of vendors (49%; 17/35) reported that they do not have one because they are not required to (Figure 33). Other surveyed vendors reported using a public restroom for hand washing (3%; 1/35), a shared hand washing station (6%; 2/35), and some (11%; 4/35) did not know. Surveyed vendors also were asked about their hand washing habits at the markets, in which many (40%; 14/35) of the vendors reported using hand sanitizer in place of hand washing when they do not have time or access to wash their hands (Figure 34). Additionally, many (37%; 13/35) of the vendors reported washing their hands at the beginning and periodically throughout the market day, while some (34%; 12/35) wash their hands often when they feel they’ve become unclean.

Chi-Square analysis of improper hand washing and glove use behaviors was used to further assess whether certain characteristics of observed farmers’ markets (i.e. location, number of vendors, and number of patrons) had an effect on observed improper behaviors (Table 3). Results from the Chi-Square analysis found that the location (indoor/outdoor) had a statistically significant (p=0.007) weak association (Cramer’s V =0.313) with the prevalence of improper hand washing or glove use observed at the farmers’ market. However, the number of vendors or patrons at the farmers’ market, which would be related to the market size, did not reveal any statistically significant associations.

Food display packaging and labeling

The display and packaging of foods were found to vary widely among observed farmers’ market vendors. High risk food display activities generally encompass instances where
unpacked foods are placed directly onto uncovered vending surfaces, in which the cleanliness and sanitation of such surface are unknown. These kinds of activities can increase the risk of cross-contamination at the farmers’ market. A small portion of vendor observations (27%; 28/102) found unpackaged foods placed directly onto uncovered vending surfaces (Figure 11). The most common displayed foods that were unpackaged and stored on uncovered vending surfaces were fresh produce, followed by raw meats and fish stored directly on ice, then apples (Figure 12). PDA inspectors reported a larger incidence of potential cross-contamination issues due to food storage and display. Approximately 43% (18/42) of the PDA inspectors found that the inspection item “contamination prevented during food preparation, storage, and display” to be in non-compliance “sometimes” with an additional 21% (9/42) of the inspectors reporting non-compliance occurring “often-almost always” (Figure 62). Food items stored improperly and lack of hand washing or proper glove use leading to potential cross-contamination, were cited as the top reasons for the non-compliance (Figure 63). In addition, a majority (42%; 18/43) of the PDA inspectors found that in-use utensils were not properly stored at the farmers’ market “sometimes” and (16%; 7/43) “often-almost always” leading to potential contamination of foods at the farmers’ market (Figure 66).

Packaging methods used by vendors also varied from vendor to vendor, and in some cases, individual vendors used multiple methods for different foods. Among the observed vendors, very few were found to have pre-packaged all of their food products prior to sale at the farmers’ market. Only 11% (11/102) of observations found vendors who pre-packaged all of their food products, while the majority (57%; 58/102) showed vendors using a combination of pre-packaging and other methods (Figure 13). The use of a plastic bag at time of sale as the sole packaging method was observed during most of (32%; 33/102) the vendor observations.
Likewise, surveyed vendors who were asked whether they pre-packaged raw produce, meats, or other raw foods, reported that some (26%; 8/31) do not pre-package those types of foods, while few (13%; 4/31) pre-package raw produce, and even fewer (10%; 3/31) pre-package raw meats or poultry. It is important to note that (39% (12/31) of the vendors did not sell raw food products (Figure 24).

In addition to the type of packaging methods used, direct observations also focused on identifying whether the pre-packaging or plastic bags used as packaging, contained vendor contact information. Forty-five percent (45%; 46/102) of vendor observations saw no contact information placed on any food packaging used by a vendor, 36% (37/102) did have the information on a label, and 15% (15/102) observed only the pre-packaged foods having a label with contact information (Figure 20). Over one-half (65%; 26/40) of the PDA inspectors reported that they “sometimes-often” found non-compliance with the inspection item “food properly labeled, original container” (Figure 60). Food packaging with no labeling and mislabeled or missing information on labels, were cited as the top reasons for the non-compliance (Figure 61). Surveyed vendors were not asked about their labeling methods.

Interestingly, a comparison of those vendors who were found to be improperly using disposable gloves or not washing hands when required, to the type of packaging used by that vendor, revealed that vendors who pre-packaged all of their food products were least likely to perform a high-risk food handling behavior. In fact, among observations involving improper glove use or hand washing, only 6% (4/65) involved vendors who pre-packaged all of their food products (Figure 21). Alternatively, 57% (37/65) of observations involving the high-risk behaviors comprised of vendors who had some of their foods pre-packaged and some bagged at time of sale, while 37% (24/65) only utilized a plastic bag for packaging at time of sale. Chi
square analysis also confirmed that comparisons of packaging methods (pre-packaging all foods vs some or none) and hand washing/proper glove (improper vs proper behaviors) use were found to be statistically associated (p=0.030) with a weak relationship (Cramer’s V = 0.215) (Table 3).

Cold storage and thermometer use

Due to the increase in TCS foods sold at farmers’ markets, vendors must have the ability to store temperature-sensitive foods properly at the farmers’ markets. In fact, a majority (70%; 71/102) of vendor observations involved instances requiring cold storage of food products at the farmers’ market (Figure 14). While portable coolers are used commonly at farmers’ markets, many indoor and outdoor markets with electrical capabilities have allowed vendors to utilize a variety of cold storage units. Interestingly, 41% (29/71) of observations involving vendors using cold storage devices found they were using electrically powered refrigerators or freezers (Figure 16). Twenty-seven percent (27%; 19/71) of observations found vendors using portable coolers with ice, some (17%; 12/71) used a deli-case filled with ice, while others (10%; 7/71) used portable coolers with no ice. A majority of surveyed vendors (88%; 23/26) reported using portable coolers with ice to store temperature sensitive foods at the farmers’ market (Figure 25). Cold storage devices themselves were not generally found by PDA inspectors to be a common non-compliance issue (Figure 56). However, common reasons for non-compliance of the inspection item “proper cooling methods used and adequate equipment for temperature control” were found to be due to inadequate temperature controls, due to a lack of the presence of a thermometer, non-working cooling devices, and vendors being unaware of how to properly cool and control the temperature of specific foods (Figure 57).

While the type of cold-storage units used by vendors were not found to be a high-risk food safety issue, the lack of thermometer usage was common. Among the 71 observations of
vendors using cold storage devices, only 9% (9/71) had a thermometer on site or in the cold storage unit (Figure 15). Twenty-eight percent (28%; 11/40) of PDA inspectors also reported that the inspection item “thermometer provided and accurate” were in non-compliance “often-almost always” with one-half of the inspectors reporting the item was “sometimes” in non-compliance (Figure 58). Additionally, the majority (67%; 26/39) of PDA inspectors stated that the non-compliance was due to thermometers not being available or used by vendors (Figure 59). Alternatively, 63% (15/24) of surveyed vendors reported that they use a thermometer at the farmers’ market (Figure 26). However, when asked the frequency of their thermometer calibration, 35% (8/23) stated they did not know how to calibrate a thermometer, 13% (3/23) never calibrated their thermometers, 9% (2/23) calibrated once every few months, and 9% (2/23) calibrated before each market day (Figure 27).

**Food samples**

In addition to finding more TCS and RTE foods products sold at farmers’ markets, the preparation and distribution of food samples at the market also has increased in popularity. Vendors were observed to be preparing or giving away food samples at the market during some (24%; 24/102) of vendor observations (Figure 17), with cheese being the most popular sampled food item (67%; 16/24) (Figure 18). Other food products prepared as food samples included milk, sausage, hummus, and jam. Among observations involving the use of food samples, toothpicks were primarily used for customer handling of samples (Figure 19). Over half (58%; 21/36) of surveyed vendors reported serving food samples, with some (38%; 8/21) of those vendors using toothpicks for customer self-service; over half (52%; 11/21) of the vendors serve customers individually, and a small number (5%; 1/21) allow customers to pick up samples with their hands (Figure 30).
Certifications and inspections

Due to the changes in food safety regulations affecting farmers’ markets in PA, farmers’ market, vendors must apply for a farmers’ market vendor license, unless exempt, due to only selling certain low-risk food products. Licensed vendors also should be inspected by a state or local health inspector. Due to these changes, it was unknown whether vendors were displaying certificates of passed food inspections, or if vendors might be seeking further food safety trainings and displaying those passed certificates.

Only a small portion of vendor observations (10%; 10/102) found vendors to be displaying any kind of food safety inspection report, license, or training certificate (Figure 10). Among PDA inspectors, many (36%; 16/44) reported that certification displays were “sometimes” in non-compliance and some (20%; 9/44) reported the item “often-almost always” in non-compliance (Figure 72). Inspectors also reported that when the item was in non-compliance it was mainly due to vendors not displaying the proper inspection certifications or licenses, the certifications or licenses were not up to date, or the vendors did not have the correct certification or license displayed (Figure 72).

Raw milk sales

The legality of raw milk sales in the U.S. depends on the particular state, and in some cases, local jurisdictions (NCSL, 2015). In Pennsylvania, raw milk and raw milk products, such as aged cheese, are allowed to be sold at farmers’ markets, if the vendor follows state guidelines (NCSL, 2015). PDA requires vendors to clearly state that a product contains raw milk on the package, as well as including a warning statement (PDA, 2011).
Among the 42 vendors observed during the direct concealed observations, 38% (16/42) of vendors and 24% (25/102) of observations were involved in the sale of raw milk or raw milk products (Table 2). In addition, 24% (6/25) of observations involving raw milk product sales were found to not have a warning label; however, 92% (23/25) of those observations found the raw milk product packaging stated raw milk as an ingredient. Vendors and inspectors were not surveyed on this topic to reduce the size and time needed to conduct those surveys.

Farmers’ market vendor needs assessment survey knowledge questions

Overall, 60% of farmers’ market vendors responded correctly to 5/8 knowledge questions posed in the vendor needs assessment survey (Figure 36). These questions covered topics on bacterial contamination, hand washing, disposable glove use, sources of pathogenic bacteria, and storage temperatures of TCS foods. Question 17 (Appendix B) of the vendor needs assessment survey was the most incorrectly answered question among knowledge questions, with half (50%; 19/38) incorrect responses and the remainder (47% 18/38) with correct responses or I don’t know (3%; 1/38). Question 17, a multiple choice question, asked vendors to choose behaviors which could cause cross-contamination at the farmers’ market. Question 20, which asked vendors to identify common foodborne pathogens found in the human nasal tract, was the second highest incorrectly answered question with 36% (14/39) of the vendors responding incorrectly, 28% (11/39) with correct responses, and 44% (17/39) of the vendors choosing “I don’t know.” Lastly, question 18, a true/false/I don’t know question, asked vendors if thermometers should be calibrated every few months, which resulted in 61% (23/38) choosing “I don’t know” and 24% (9/38) choosing the incorrect response.
Farmers’ market vendor needs assessment survey attitudinal questions

Using a 5-point Likert scale, farmers’ market vendors were asked to respond to 8 questions asking vendors to choose the degree to which they agree or disagree with the provided statements (Appendix B). Statements were focused on topics related to food safety regulations, vendor knowledge of food safety, and food safety-related concerns of vendors. On average, vendors were in agreement (>3; Likert scale value) with 4/8 statements, and were near neutral (3) on the remaining statements (Figure 37). The lowest average agreement value (2.2) was from question 25 (Appendix B), which was designed to determine whether vendors had difficulty putting their food safety knowledge into practice. Question 30 was in the highest agreement (4.6), which asked vendors whether they would change their practices if they discovered their food products were contaminated. Surprisingly, question 23 resulted in the second highest agreement (4.2), which gauged vendor’s responses to the statement “PDA licensing requirements and inspections are important to keep foods sold at farmers’ markets safe”.

Vendor training preferences

Aside from assessing the knowledge and attitudes of farmers’ market vendors on retail food safety, the vendor needs assessment survey also was used to determine learning and training preferences of vendors for future development of educational programming in food safety. Interestingly, 100% of surveyed farmers’ market vendors had some kind of previous education or training in food safety (Table 6). Specifically, half (50%; 7/14) had taken ServSafe© or similar courses at some time, some (29%; 4/14) had taken a Cooperative Extension course in food safety, and the remainder of vendors had training from a previous employer, college course taken over the internet, or other source.
When asked to choose their preferred method of training, the most chosen method was in-person training in a small group, in a classroom setting (51%; 20/39), followed by computer-based training (33%; 13/39) (Table 7). When asked to choose their preference on training techniques, a majority (74%; 28/38) selected hands on exercises, (58%; 22/38) chose pictures, videos, or watching other people performing an activity, and between 24% to 26% (9-10/38) of vendor vendors chose studying for a test, playing games, or one-on-one instructor time as the third most selected training technique (Table 8).

When asked whether vendors would attend a food safety workshop hosted by Penn State, 39% (15/38) of surveyed vendors stated they would attend if the program was free, 37% (14/38) would attend and would pay $25 to 50, 5% (2/30) would attend and pay $50 to $100, and 32% (12/38) would not attend a training program under any circumstances (Table 9). Lastly, surveyed vendors were asked where they would be willing to travel to receive food safety training. Only 8% (3/39) were willing to travel to University Park, and between 36% and 44% (14-17/39) of vendors would only travel to the nearest PSU satellite campus, Extension office, public hall or school, or the farmers’ market which they sell at. In addition, 23% (9/39) preferred not to travel and would rather receive training over the internet (Table 10).

Farmers’ market manager structured group interview

Farmers’ market manager structured group interview responses were transcribed from an audio recording and individual manager responses for each question were compiled. Manager responses were organized and transformed into major common themes, which reflect the overall opinions and feelings of market managers for each question (Table 14-20). Based on the time allotted (60 min) and the responses provided from market managers from initial questions, questions 7, 8, and 10 were not asked during the group interview session (Appendix E).
Market manager participant experience

In total, 8 market managers participated in the structured group interview which included 6 female and 2 male managers with a wide range of experience and knowledge working with farmers, vendors, and farmers’ markets (Table 14). Participant’s experience as market managers ranged from 1 month to 10 or more years, with some managers responsible for multiple markets, multiple managers, and between 15 to 80 vendors. No additional demographic information was collected.

What is the role of the farmers’ market manager?

There was general agreement among market manager participants on their roles as market managers. Depending on the size of the markets they managed, managers described differences in the number of responsibilities. Six common themes were identified from market manager responses on their roles as a market manager, including the following: managing overall operations of the market; mentoring and supporting vendors, supporting local economy and providing public service; marketing and advertising; and planning for market events (Table 15).

Is food safety something to worry about at farmers’ markets?

Overall, there was a general agreement among market managers on whether food safety was something to worry about at farmers’ markets. However, there appeared to be a spectrum of concern regarding the risks. Four common themes were identified from market manager responses on this topic, including: not a concern for most managers; market managers do not have time to worry about food safety so they trust their vendors; market managers assume vendors are being inspected at other markets; and a concern that regulatory enforcement is inconsistent between jurisdictions and markets (Table 16).
When it comes to hand washing and providing hand washing stations at the farmers’ market, why do you think there is a difference between what our researchers and PDA inspectors see, versus what the vendors say they are doing?

Market manager responses to this question were found to be in general agreement, which provided important perspectives on hand washing at farmers’ markets. Four common themes were identified from market manager responses to this topic, which included: food safety regulations are confusing in PA and vendors may not understand current hand washing rules; it is difficult to put into practice the current hand washing rules at actual farmers’ markets; current hand washing regulations may not be practical; and vendors won’t change their hand washing habits unless they are told to by a government official (Table 17).

When it comes to thermometer use at the market, why do you think there is a difference between what our researchers and PDA inspectors see, versus what the vendors say they are doing?

Responses from market managers to this question were relatively quick and in agreement, showing an overall consistent understanding in issues related to thermometer use at farmers’ markets. Three common themes were identified from market manager responses to this question which included: market managers are aware their vendors do not have thermometers, but do not act on that knowledge; market managers have heard vendors say they do not have thermometers because the inspectors bring their own anyway; and market managers believe vendors understand how to properly manage temperature control at the market regardless of thermometer use (Table 18).

What are your thoughts and opinions on providing food safety training to vendors, and if you had to develop a program, how would you deliver the training, and what kinds of key areas would you cover?

Market manager responses to this questions were in general agreement, although some managers had different ideas regarding certain elements of the question. Four common themes
were identified from market manager responses which included: market managers do not want to be responsible for food safety training or managing food safety issues; managers believe PA Act 106 is focused on vendors, not market managers, so training should be as well; managers would like to see simple pamphlets or YouTube videos as training tools; and vendors might attend training if it was incorporated into another event which they already attend (Table 19).

What are your thoughts and opinions on providing food safety training to vendors using either a web-based program which is self-run, self-paced, produces a certificate of completion, and requires no formal instruction, or a flip book style training (show example), which you as a market manager could present to your vendors, which also requires no prior knowledge or background in food safety?

Market manager’s initial responses to this question were in agreement, however over the period of discussion, some vendors changed their initial opinions on the types of training tools presented in the question. Three common themes were identified from market manager responses which included: some market managers do not like the idea of a flipbook, while others see the value of its use in the market setting; managers think that any computer-based training must also be provided in an alternate form, due to low computer literacy or lack of computer use among certain vendor groups (i.e. elderly, Amish); and among managers who liked the idea of a flipbook, they believe that the way it is used and presented will be important to avoid vendors feeling patronized (Table 20).

Discussion

The results of the comprehensive needs assessment revealed important farmers’ market vendor gaps in retail food safety behaviors, knowledge, and attitudes. The use of methodology triangulation consisting of direct concealed observations, PDA public health inspector surveys, and vendor surveys, provided a view of actual vendor behaviors during normal market conditions, vendor behaviors during health inspections, and self-reported behaviors of vendors.
In other words, the results show what vendors say they do versus what they actually are observed to do in reality, further increasing the validity of the assessment. The results also demonstrate whether researcher’ collected observations coincide with PDA health inspector inspection results and observations. The use of both direct concealed observations and multiple survey tools provides a more realistic, valid, and practical assessment of farmers’ market vendor retail food safety.

**Vendor hygiene and vending area conditions**

Overall, both the direct concealed observational analyses and PDA inspector survey results did not reveal a high percentage of instances of poor vendor personal hygiene. Alternatively, an observational assessment of farmers’ markets in Rhode Island found that 81% (21/26) of observed vendors had unclean clothing (Vandeputte et al., 2014). These results suggest that differences in food safety oversight or size and popularity of farmers’ markets between U.S. states could influence efforts made by vendors to maintain good personal hygiene at the farmers’ market.

Observed vending surfaces also were found to be clean during 89% of observations. However, over half of observed vending surfaces were found to be made of wood. Although 56% of PDA inspectors “rarely” or “almost never” found “food and food contact surfaces used by vendors” to be in non-compliance, 72% of PDA inspectors reported that when the item was out of compliance it was due to surfaces being made of un-cleanable materials such as wood. Additionally, 70% of PDA inspectors also reported that food contact surfaces were not cleaned or sanitized “sometimes – almost always,” providing further evidence that vendors may not be cleaning food contact surfaces properly or using surfaces that cannot be properly cleaned or sanitized, such as wood. These results are in contrast to responses from surveyed vendors, in
which only 8% reported they do not or do not know if they clean their vending stand, while the
remainder indicated that they cover their vending stands or clean them with either soap and
water, sanitizing wipes, or chlorine/bleach. While it is possible that the select group of surveyed/vendors may be honestly reporting their behaviors, these results are in contrast with both vendor
observations and PDA inspection outcomes.

Disposable glove use

Traditionally, disposable glove use at farmers’ markets has been viewed as something
only required if cooking and serving prepared foods at the farmers’ market. Due to the increase
in TCS and RTE foods sold at farmers’ markets, and the increase in regulatory oversight of those
vendors in PA, the increased use of disposable gloves was expected. In reality, disposable glove
use at PA farmers’ markets remains minimal, even among vendors who sell unpackaged RTE
foods. Among vendor observations, only 24% found disposable gloves to be present at a
vending stand, regardless of the foods sold. This observation was further substantiated by
surveyed vendors who reported that 34% used disposable gloves, despite the fact that a majority
of surveyed vendors sold TCS and RTE foods at the same stand. Within the group of vendors
observed to be using disposable gloves, slightly less than one-half were found to use them
improperly. The handling of money then unpackaged foods without changing gloves, was found
to be the most common improper glove use behavior. PDA inspectors also noted that more often
than not, disposable gloves were found to be used improperly during inspections, with the
handling of money being the most common reason for a non-compliance among improper glove
users. Additionally, a majority of PDA inspectors also reported that vendors commonly receive
non-compliance for handling RTE foods with bare hands. Interestingly, just over one-half of
surveyed vendors stated that they avoid bare hand contact with foods by pre-packaging, while
the remainder use utensils or plastic bags to avoid touching foods. These results may suggest that there is a general lack of understanding among vendors on when to use disposable gloves, when to change gloves, and what kinds of behaviors are unacceptable while wearing gloves. Disposable glove use at farmers’ markets in PA will likely continue to become a more important issue as RTE food vendors and mobile kitchens or food trucks continue to grow in popularity and presence throughout the state.

*High risk food handling behaviors and hand washing habits*

Like disposable glove use, the use of hand washing at farmers’ markets is seldom observed. While the majority of improper hand washing behaviors observed by researchers and also noted by PDA inspectors includes the handling of money (87%) then touching unpackaged foods, the overall lack in the presence of proper hand washing facilities observed at farmers’ markets in PA also was found to be concerning. Furthermore, other high-risk behaviors were observed by researchers including handling raw foods then RTE foods and eating, coughing, sneezing then handling unpackaged foods without washing hands in between those behaviors. Although the percentage of those latter behaviors were observed to be low (15%), isolated foodborne incidents related to one vendor could have cascading effects on farmers’ markets across the state.

Other studies have found similar results related to hand washing. In fact, Behnke et al. (2012), reported that among 18 observed RTE farmers’ market vendors in Indiana, hand washing was observed only twice among 417 instances where it was required. Touching personal belongings, clothing, money then handling RTE foods were identified as the most significant violations. Vandeputte et al. (2014), also observed that the majority (93%; 13/14) of farmers’ market vendors observed in Rhode Island did not have hand washing facilities available and
none of the vendors were observed to wash their hands during market hours. Similarly, among 17 farmers’ market cheese vendors observed in Ontario, Canada, 88% of vendors did not wash their hands before or after serving patrons cheese, even though 76% of vendors had a hand washing sink on the premises (Teng, Wilcock, and Aung, 2004). These results suggest that the lack of use of hand washing at farmers’ markets by vendors may not be specific to Pennsylvania, but is a nationwide issue. Furthermore, with the increase in food samples being prepared and served at farmers’ markets, the importance of proper hand washing habits will become even more vital.

Interviewed farmers’ market managers suggested that the lack of hand washing observed could be the result of a lack of understanding from vendors on the current hand washing rules in each state. Market managers also noted that at many times, it can be impractical or inconvenient for vendors to stop to wash their hands between transactions, due to the volume of customers and the resources available to vendors at farmers’ markets. These conclusions are further supported by surveyed vendor responses, in which 49% reported that they do not have a hand washing station because they are not required to, and 40% use hand sanitizer in place of hand washing when they do not have time or access to wash their hands. Furthermore, market managers stated that vendors would likely not change their hand washing behaviors until they were told to do so by a government official.

Another factor which may contribute to this issue, is that farmers could be following the same general hygiene and food handling practices which they use on the farm. Harrison et al. (2013) found that among 226 surveyed farmers in three southern U.S. states, only 67% and 64% reported having a hand washing and bathroom facility near the field and packing shed, respectively, while 50% harvested crops with bare hands and only 41% offered sanitation
training for workers. In addition, 56% of the same surveyed farmers indicated they use manure for crop fertilizer; however, only 45% reported following correct composting waiting times and application period guidelines.

It is clear that a multi-faceted approach is necessary, to not only provide vendors education on the importance of hand washing and when it is necessary, but find easy-to-use hand washing solutions or techniques which vendors can easily implement at the farmer’s market, even during peak market hours. In addition, it may be advantageous for local and state regulators to provide vendors with clear guidelines on hand washing regulations, while increasing oversight of farmers’ markets in each state.

Packaging, labeling, and food display

Due to the wide range of environmental conditions faced at farmer’s markets in PA and the observed lack of proper hand washing and disposable glove use at farmers’ markets, good display and packaging methods could alleviate many of the food safety risks caused by the identified vendor behaviors occurring at the farmers’ market. Fortunately, a majority of vendor observations found vendor food display surfaces to be clean, although 27% of observations found unpackaged foods to be placed directly on uncovered vending surfaces, with a majority of those surfaces being wood. PDA inspectors also reported a high percentage of non-compliance due to vending surfaces being made of un-cleanable surfaces like wood which are not covered, and the lack of proper cleaning and sanitizing of those food contact surfaces. Alternatively, 92% of surveyed vendors reported that they either cover their food stand properly or clean and sanitize those surfaces. Similar results were observed by Teng, Wilcock, and Aung (2004), who found that 29% of cheese vendors at Ontario farmers’ markets had obvious signs of vending area uncleanliness, although 94% used cleanable vending surfaces. These results may suggest that
while vendors may be aware that proper covering or cleaning and sanitizing of vending surfaces may be important to reduce food safety risks, these behaviors may not be practiced by some vendors at the farmers’ market.

Risks associated with unclean vending surfaces also can be exacerbated by the lack of pre-packaging of TCS and RTE foods placed on those surfaces. In this study, only 11% of the vendors pre-packaged 100% of their food products, while 57% had some pre-packaged, and 32% used a plastic bag as packaging at the time of sale. Surveyed vendors also reported that 26% do not pre-package any of their raw food products, while 23% pre-package only certain foods like raw meats or produce, suggesting that most vendors only use pre-packaging for some foods but not all. Interestingly, an analysis of packaging methods used by vendors who were observed to perform improper hand washing or glove use behaviors, found that vendors who pre-packaged 100% of their food products were least likely to perform improper hand washing or glove use behaviors. While pre-packaging is a well-used practice in the commercial food industry, the benefits of pre-packaging do not appear to be currently realized by most farmers’ marker vendors in PA. The use of pre-packaging at farmers’ markets has the potential to alleviate the risks of vendors not utilizing proper hand washing and proper disposable glove use, in addition to mitigating risks due to the use of un-cleanable vending surfaces. Future training and food safety education for vendors could focus on providing cheap and easy methods of pre-packaging foods for sale at farmers’ markets.

Cold storage and thermometer use

As farmers’ markets and vendors have evolved over the past decade, the types of foods offered by vendors which require cold storage also has increased. In response, many vendors have been observed to use commercial-like electrically powered refrigeration and freezer
devices; however the use of portable coolers remains most popular. While vendor observations and PDA inspection results have revealed few issues related to the type of cold storage units used by vendors, an overall lack of thermometer use at farmers’ markets has been identified. Among vendor observations, only 9% of observations found vendors to have a thermometer on site or in the cold storage unit. A majority of PDA inspectors also indicated that non-compliance were sometimes-almost always issued for thermometers not being available or used by vendors.

In a related study, only 16% of cheese purchased from Ontario farmers’ market vendors were found to be held properly below 5°C, with temperatures ranging from 14 to 21°C (Teng, Wilcock, and Aung, 2004). In contrast, 63% of surveyed vendors in this study, reported using a thermometer at farmers’ markets; however 35% stated they did not know how to calibrate a thermometer and 13% never calibrated one before. Interviewed market managers also stated that they were aware that most of their vendors do not have or use a thermometer, although they were generally confident that their vendors were storing foods at the proper temperatures. Market managers also noted that some vendors do not use a thermometer because the health inspector uses their own thermometer during inspections anyway. Based on these results, it is clear that like hand washing, thermometer use at farmers’ markets is rarely occurring, even among vendors storing foods cold at the farmers’ market. Results from two knowledge questions of the vendor survey also revealed a lack of knowledge on proper thermometer use and calibration. In fact, the two questions which focused on thermometer calibration and thermometer sanitation were the most incorrectly answered questions among knowledge questions.

These outcomes suggest that the absence of thermometer use at farmers’ markets may be a result of a lack of knowledge on how to use thermometers properly and their importance in food safety. It may also be advantageous for regulatory agencies to not only provide simple
guidelines for vendors on thermometer use, but also to provide cheap and accessible resources for vendors to acquire proper thermometers which are capable of being calibrated. Future training for farmers’ market vendors, which provide hands-on training in thermometer use, also could help alleviate the food safety risks associated with a lack of thermometer use at farmers’ markets.

Labeling and certifications

While the act of properly labeling foods with vendor contact information and displaying licenses and certifications may not directly impact food safety risks at farmers’ markets, they can be very important in instances of foodborne illness associated with foods sold at farmers’ markets. Vendor observations and PDA inspector inspection results suggest that vendors are unaware of both the requirements and importance of proper labeling for traceability purposes. Slightly less than one-half (45%) of vendor observations found contact information provided on food packaging, while 15% found that contact information was provided only on the pre-packaged foods. In addition, only 10% of vendor observations found any kind of license or certification displayed at the vending area. PDA inspectors also reported that the requirements for displaying licenses and certifications at the vending area were more often than not in non-compliance.

A case in point demonstrating the potential problems associated with poor traceability of farmers’ market products was a 2011 Oregon strawberry outbreak (Goetz, 2011). Epidemiologists noted that tracing the source of the outbreak was made even more difficult due to the numerous farmers’ market stands which sold strawberries with no labeling and no way of differentiating which farms they originated from. This outbreak resulted in Oregon health departments only being able to provide vague public health notices informing consumers not to
eat strawberries from Northwest Oregon farm stands, and in turn, affecting the entire local strawberry industry rather than one farm or vendor.

Furthermore, vendor observations of improper raw milk product labeling in this study further demonstrates that farmers’ markets vendors may not know or understand the requirements and benefits of basic food product labeling. These results may be of great importance to public health regulators, and future efforts to ensure vendors provide basic labeling information on their products could prevent major hindrances to outbreak investigations and avoid alienating entire local agricultural industries during foodborne incidents.

**Vendor knowledge, attitudes, and training preferences**

Surveyed vendors demonstrated knowledge of several retail food safety related topics by providing correct responses to knowledge questions. These question topics included: cross-contamination, personal hygiene, hand washing and glove use, TCS food temperature control, and sources of pathogens at farmers’ markets. In contrast, vendors demonstrated poor knowledge of proper thermometer sanitation, thermometer calibration, and identification of bacterial pathogens by name and sources. Similar results were found by McIntyre et al. (2014), who reported that a majority of the 107 farmers’ market vendors surveyed in British Columbia, were able to successfully answer knowledge questions related to hand-washing, personal hygiene, and cross-contamination, however identification of potentially hazardous foods caused difficulty for those surveyed vendors.

Results from the attitudinal assessment section of the vendor survey suggests that vendors are not generally concerned about pathogenic bacteria in their foods, however they feel they have difficulty putting the food safety knowledge they have into practice, and do not necessarily feel they have sufficient knowledge in food safety. Alternatively, surveyed vendors do think PDA
licensing requirements and inspections are important to keep foods safe at farmers’ markets and vendors would change their food safety practices if they discovered they were contaminated with harmful bacteria. The results from the knowledge and attitudinal assessment may suggest that there are some key food safety topics in which vendors are knowledgeable, such as hand washing. However, based on the results of the observational assessment and PDA inspection outcomes, this knowledge does not appear to be translated into proper behaviors at the farmers’ market. Furthermore, the most noticeable and virtually universal improper behaviors, such as thermometer use, reflected topics which also were much less understood by surveyed vendors.

Vendor training preferences

In an effort to further prepare and translate the results of the comprehensive needs assessment into practical and useful educational materials and potential future training programming for vendors, the learning and training preferences of vendors were assessed. Interestingly, a majority of surveyed vendors chose a classroom setting training (face-to-face) as their preferred method, followed by computer-based training, and one-on-one in-person training chosen the least. This finding may not be surprising considering 51% of surveyed vendors were above the age of 44, and may not be as comfortable with computer-based training, as compared to the younger age groups. These results also echo statements by interviewed farmers’ market managers who suggested that computer-based training may not be suitable for older aged vendors. Surveyed vendors also preferred hands-on exercises and demonstrations through pictures or videos, as compared to group exercises, tests, or playing games. These comments echo statements made by farmers’ market managers who suggested YouTube videos could be suitable training tools for vendors. Lastly, surveyed farmers’ market vendors were much more likely to attend a food safety training program if it was free or less than $50, but would only be
willing to travel to local county Cooperative Extension offices, public halls, schools, or farmers’ markets. Based on these preferences, future training programming for farmers’ market vendors should encompass hands-on activities with numerous pictures or videos, and be held in smaller groups at central locations within short driving distances of major farmers’ market venues.

**Conclusions**

Through the use of a direct concealed observational assessment, a farmers’ market vendor needs assessment survey, and PDA public health inspector needs assessment survey, important gaps in vendor retail food safety behaviors, knowledge, and attitudes were identified. Specifically, vendors were found to demonstrate sufficient knowledge in certain food safety topics such as hand washing, personal hygiene, and cross-contamination; however, this knowledge was not translated into proper food safety behaviors at farmers’ markets. Future behavioral exercises designed to test vendors in these skills could reveal more insight into why vendor knowledge may or may not translate into proper retail food safety behaviors at the farmers’ market. Overall, observations of vendor-related retail food safety behaviors and PDA inspector-reported inspection outcomes coincided, while vendor self-reported behaviors were counter to those behaviors observed by the researchers. Opinions, interpretations, and ideas offered from interviewed farmers’ marker managers also provided additional insight into why vendors may have knowledge in certain areas which are not translated into good retail practices. Based on these outcomes, it has been concluded that farmers’ market vendors in PA would greatly benefit from an interactive classroom-based training program, customized to address food safety risks and requirements specifically associated with farmers’ markets.
References


Tables

Table 1: Summary of direct concealed observations performed at Pennsylvania farmers’ markets.

<table>
<thead>
<tr>
<th>Number of farmers’ markets observed</th>
<th>Number of farmers’ market observation sessions</th>
<th>Number of vendors observed</th>
<th>Number of vendor observation sessions</th>
<th>Time Period</th>
<th>Number of single observations performed/vendor</th>
<th>Total single observations performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=8</td>
<td>n=22</td>
<td>n=42</td>
<td>n=102</td>
<td>Jan-Aug</td>
<td>n=10-26</td>
<td>n=1020-2652</td>
</tr>
<tr>
<td>Market (Indoor)</td>
<td>Market (Outdoor)</td>
<td>Market (Church)</td>
<td>Market (Large Barn/Warehouse)</td>
<td>Market (City center)</td>
<td>75% (6/8)</td>
<td>25% (2/8)</td>
</tr>
<tr>
<td>14% (6/42)</td>
<td>26% (11/42)</td>
<td>60% (25/42)</td>
<td>38% (16/42)</td>
<td>24% (25/102)</td>
<td>24% (6/25)</td>
<td>92% (23/25)</td>
</tr>
</tbody>
</table>

Table 2: Direct concealed observations of raw milk sales at Pennsylvania farmers’ markets.

<table>
<thead>
<tr>
<th>Number of vendors selling raw milk or raw milk products</th>
<th>Number of observations of vendors selling raw milk products</th>
<th>Observations of raw milk product packaging not containing a warning label</th>
<th>Observations of raw milk product packaging showing raw milk as an ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>38% (16/42)</td>
<td>24% (25/102)</td>
<td>24% (6/25)</td>
<td>92% (23/25)</td>
</tr>
</tbody>
</table>
Table 3: Chi-Square analysis of hand washing/glove use behaviors vs packaging methods, market location, number of vendors, and number of patrons.

<table>
<thead>
<tr>
<th></th>
<th>Number of Vendors observed performing improper hand washing or glove use</th>
<th>Number of Vendors observed performing proper hand washing or glove use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-packaged 100% of food products</td>
<td>3</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Some or none of food products pre-packaged</td>
<td>56</td>
<td>35</td>
<td>91</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59</strong></td>
<td><strong>43</strong></td>
<td><strong>102</strong></td>
</tr>
<tr>
<td>Pearson Chi-Square (α=0.05)</td>
<td></td>
<td></td>
<td>0.030</td>
</tr>
<tr>
<td>Cramer’s V (α=0.05)</td>
<td></td>
<td></td>
<td>0.215 (p=0.030)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of Vendors observed performing improper hand washing or glove use</th>
<th>Number of Vendors observed performing proper hand washing or glove use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Market</td>
<td>50</td>
<td>34</td>
<td>84</td>
</tr>
<tr>
<td>Outdoor Market</td>
<td>11</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61</strong></td>
<td><strong>39</strong></td>
<td><strong>102</strong></td>
</tr>
<tr>
<td>Pearson Chi-Square (α=0.05)</td>
<td></td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>Cramer’s V (α=0.05)</td>
<td></td>
<td></td>
<td>0.313 (p=0.007)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of Vendors observed performing improper hand washing or glove use</th>
<th>Number of Vendors observed performing proper hand washing or glove use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50 patrons</td>
<td>30</td>
<td>29</td>
<td>61</td>
</tr>
<tr>
<td>More than 50 patrons</td>
<td>31</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61</strong></td>
<td><strong>39</strong></td>
<td><strong>102</strong></td>
</tr>
<tr>
<td>Pearson Chi-Square (α=0.05)</td>
<td></td>
<td></td>
<td>0.022</td>
</tr>
<tr>
<td>Cramer’s V (α=0.05)</td>
<td></td>
<td></td>
<td>0.274 (p=0.022)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of Vendors observed performing improper hand washing or glove use</th>
<th>Number of Vendors observed performing proper hand washing or glove use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 vendors</td>
<td>30</td>
<td>29</td>
<td>61</td>
</tr>
<tr>
<td>More than 25 vendors</td>
<td>31</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61</strong></td>
<td><strong>39</strong></td>
<td><strong>102</strong></td>
</tr>
<tr>
<td>Pearson Chi-Square (α=0.05)</td>
<td></td>
<td></td>
<td>0.022</td>
</tr>
<tr>
<td>Cramer’s V (α=0.05)</td>
<td></td>
<td></td>
<td>0.274 (p=0.022)</td>
</tr>
</tbody>
</table>
Table 4: Additional observations of Pennsylvania farmers’ market vendors recorded through the “Food Safe Survey” smartphone application (direct concealed observations).

<table>
<thead>
<tr>
<th></th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>Unpasteurized apple cider stored at room temperature.</td>
</tr>
<tr>
<td>O2</td>
<td>Raw goat milk stored in ice which covered only half of the container.</td>
</tr>
<tr>
<td>O4</td>
<td>Soiled egg cartons re-used for fresh eggs.</td>
</tr>
<tr>
<td>O5</td>
<td>Raw, fresh pasta stored at room temperature.</td>
</tr>
<tr>
<td>O6</td>
<td>Coolers of fresh meat and dairy products kept open for advertising.</td>
</tr>
<tr>
<td>O7</td>
<td>Young children under age 18 bagging foods and collecting money without supervision.</td>
</tr>
<tr>
<td>O8</td>
<td>Handling raw meat with butcher paper and not washing hands.</td>
</tr>
<tr>
<td>O9</td>
<td>Preparing bags of mixed greens at the market without washing hands or using gloves.</td>
</tr>
<tr>
<td>O10</td>
<td>Re-using cloth rags to clean surfaces and not washing or storing rags in sanitizer following use.</td>
</tr>
<tr>
<td>O11</td>
<td>Electric deli-cases being used to store TCS foods, and were either not turned on, or not working properly.</td>
</tr>
<tr>
<td>O12</td>
<td>Vendors licking fingers prior to handling plastic bags for packaging to gain grip on single bags.</td>
</tr>
</tbody>
</table>

Note: “O” used to abbreviate observation.
Table 5: Farmers’ market vendor demographic survey results, Q31 “have you ever taken any food safety classes?” (n=39).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36% (14/39)</td>
<td>62% (24/39)</td>
<td>3% (1/39)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses.

Table 6: Farmers’ market vendor demographic survey results, Q32 “what types of food safety courses have you taken?” (n=14).

<table>
<thead>
<tr>
<th>College courses taken in person or over the internet</th>
<th>Cooperative Extension courses taken in person or over the internet</th>
<th>ServSafe or other food safety certification course</th>
<th>Food safety training from a current or previous employer</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>21% (3/14)</td>
<td>29% (4/14)</td>
<td>50% (7/14)</td>
<td>29% (4/14)</td>
<td>14% (2/14)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each vendor.

Table 7: Farmers’ market vendor demographic survey results, Q33 “what is your preferred method of receiving training or learning something? (check all that apply)” (n=39).

<table>
<thead>
<tr>
<th>Computer-based training with power point slides</th>
<th>Computer-based training with videos</th>
<th>In person training (classroom setting) in a large group</th>
<th>In person training (classroom setting) in a small group</th>
<th>In person training outside of the classroom (at the market, farm, or worksite)</th>
<th>One-on-one in person training (at the market, farm, or worksite)</th>
<th>I do not know</th>
</tr>
</thead>
<tbody>
<tr>
<td>33% (13/39)</td>
<td>26% (10/39)</td>
<td>21% (8/39)</td>
<td>51% (20/39)</td>
<td>26% (10/39)</td>
<td>23% (9/39)</td>
<td>5% (2/39)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each vendor.
Table 8: Farmers’ market vendor demographic survey results, Q34 “when you are being taught something, which of the following techniques help you learn better? (check all that apply)” (n=38).

<table>
<thead>
<tr>
<th>Hands on exercises</th>
<th>Group exercises</th>
<th>Pictures, videos, or watching other people doing the activity that you are being taught</th>
<th>Studying for a test</th>
<th>Playing a game to help remember the lessons</th>
<th>One on one time with the instructor to ask questions and review the lesson</th>
<th>Other</th>
<th>I do not know</th>
</tr>
</thead>
<tbody>
<tr>
<td>74% (28/38)</td>
<td>13% (5/38)</td>
<td>58% (22/38)</td>
<td>24% (9/38)</td>
<td>26% (10/38)</td>
<td>24% (9/38)</td>
<td>3% (1/38)</td>
<td>5% (2/38)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each vendor.

Table 9: Farmers’ market vendor demographic survey results, Q35 “I would attend a food safety training workshop hosted by Penn State (check all that apply)” (n=38).

<table>
<thead>
<tr>
<th>Yes, but only if it is free</th>
<th>Yes, and I would be willing to pay $25 to $50</th>
<th>Yes, and I would be willing to pay $50 to $100</th>
<th>No, but I would like information on food safety pertaining to my food products</th>
<th>No, and I do not want any additional assistance or information from Penn State</th>
</tr>
</thead>
<tbody>
<tr>
<td>39% (15/38)</td>
<td>37% (14/38)</td>
<td>5% (2/38)</td>
<td>24% (9/38)</td>
<td>8% (3/38)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each vendor.

Table 10: Farmers’ market vendor demographic survey results, Q36 “where would you be willing to travel to receive food safety training? (check all that apply)” (n=39).

<table>
<thead>
<tr>
<th>University Park</th>
<th>Penn State University (closest satellite campus)</th>
<th>Closest county Extension office</th>
<th>The farmers’ market which I sell at</th>
<th>A public hall or school in my home town</th>
<th>I would not travel farther from my own home for training</th>
<th>I would prefer not to travel, but would receive training from an internet site</th>
<th>I do not know</th>
</tr>
</thead>
<tbody>
<tr>
<td>8% (3/39)</td>
<td>36% (14/39)</td>
<td>44% (17/39)</td>
<td>44% (17/39)</td>
<td>38% (15/39)</td>
<td>3% (1/39)</td>
<td>23% (9/39)</td>
<td>10% (4/39)</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each vendor.
Table 11: PDA public health inspector survey results, Q1 “how many farmers’ markets vendors have you inspected in the last three years?” (n=44).

<table>
<thead>
<tr>
<th></th>
<th>1-5</th>
<th>6-15</th>
<th>16-30</th>
<th>31-50</th>
<th>51-70</th>
<th>More than 70</th>
<th>I do not know</th>
</tr>
</thead>
<tbody>
<tr>
<td>22% (10/44)</td>
<td>18% (8/44)</td>
<td>6% (3/44)</td>
<td>11% (5/44)</td>
<td>13% (6/44)</td>
<td>25% (11/44)</td>
<td>2% (1/44)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses.

Table 12: PDA public health inspector survey results, Q2 “which types of food categories were being sold by the vendors you have inspected?” (n=44).

<table>
<thead>
<tr>
<th></th>
<th>Pre-packaged, non-potentially hazardous foods</th>
<th>Pre-packaged, potentially hazardous foods</th>
<th>RTE on the premises foods</th>
<th>Other</th>
<th>All of the above</th>
<th>I do not know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>34% (15/44)</td>
<td>32% (14/44)</td>
<td>25% (11/44)</td>
<td>7% (3/44)</td>
<td>71% (31/44)</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each inspector.

Table 13: PDA public health inspector survey results, Q3 “which types of food items were being sold by the vendors you have inspected?” (n=44).

<table>
<thead>
<tr>
<th></th>
<th>Produce (fruits and vegetables)</th>
<th>Unpasteurized milk</th>
<th>Pasteurized milk</th>
<th>Other dairy products</th>
<th>Eggs</th>
<th>Meat</th>
<th>Poultry</th>
<th>Fresh/ frozen seafood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>82% (36/44)</td>
<td>39% (17/44)</td>
<td>39% (17/44)</td>
<td>71% (31/44)</td>
<td>71% (31/44)</td>
<td>77% (33/44)</td>
<td>68% (30/44)</td>
<td>32% (14/44)</td>
</tr>
<tr>
<td>Raw sausages</td>
<td>RTE cooked or fermented sausages</td>
<td>Baked Breads</td>
<td>Other baked goods</td>
<td>Canned fruit products</td>
<td>Other canned goods</td>
<td>Sauces, salsas, dressings</td>
<td>Unpasteurized juices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41% (18/44)</td>
<td>36% (16/44)</td>
<td>86% (38/44)</td>
<td>80% (35/44)</td>
<td>77% (34/44)</td>
<td>80% (19/44)</td>
<td>68% (30/44)</td>
<td>18% (8/44)</td>
</tr>
<tr>
<td>RTE cooked foods prepared at the market</td>
<td>Other</td>
<td>All of the above</td>
<td>I do not know</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>64% (28/44)</td>
<td>9% (4/44)</td>
<td>11% (5/44)</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Sum of rows may be greater than 100% due to rounding and multiple responses; data reflects multiples responses from each inspector.
Table 14: Market manager structured group interview results, Q1 manager descriptions (n=8).

<table>
<thead>
<tr>
<th>Participant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (F)</td>
<td>10 years’ experience as a market manager, currently manage 45 vendors.</td>
</tr>
<tr>
<td>2 (F)</td>
<td>Former farmers’ market manager, current coordinator for a local agricultural promotion program which supports vendors and farmers’ markets.</td>
</tr>
<tr>
<td>3 (F)</td>
<td>2 years’ experience as a market manager, currently manage 18 vendors.</td>
</tr>
<tr>
<td>4 (M)</td>
<td>3 years’ experience managing a farmers’ market management association, coordinate operations for 16 farmers’ markets and 80 vendors.</td>
</tr>
<tr>
<td>5 (M)</td>
<td>10 years’ experience as a market manager, previously worked at 3 other markets, currently manage 15 vendors.</td>
</tr>
<tr>
<td>6 (F)</td>
<td>3 years’ experience as an assistant market manager, currently manage 3 markets.</td>
</tr>
<tr>
<td>7 (F)</td>
<td>7 years’ experience as a market manager, currently manage 3 markets</td>
</tr>
<tr>
<td>8 (F)</td>
<td>1 month experience as a market manager, 3 years’ previous experience as an assistant market manager.</td>
</tr>
</tbody>
</table>

Note: (F/M): Female/Male.

Table 15: Market manager structured group interview results, Q2 common themes (n=8).

<table>
<thead>
<tr>
<th>Q2: What is the role of the farmers’ market manager?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common themes</strong></td>
</tr>
<tr>
<td>1 Manage the operations of the market.</td>
</tr>
<tr>
<td>2 Mentor and support vendors in their business of selling their food products.</td>
</tr>
<tr>
<td>3 Support economic and community development.</td>
</tr>
<tr>
<td>4 Providing public awareness of local agriculture and its benefits to society.</td>
</tr>
<tr>
<td>5 Marketing and advertising.</td>
</tr>
<tr>
<td>6 Planning and logistics for events, entertainment, and day-day operations.</td>
</tr>
</tbody>
</table>

Table 16: Market manager structured group interview results, Q3 common themes (n=8).

<table>
<thead>
<tr>
<th>Q3: Is food safety something to worry about at farmers’ markets?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common themes</strong></td>
</tr>
<tr>
<td>1 Not a concern for most market managers.</td>
</tr>
<tr>
<td>2 Market managers don’t have the time to provide oversight so they must trust their vendors are practicing good food safety habits.</td>
</tr>
<tr>
<td>3 Market managers assume vendors are being inspected at other markets they attend, even if they don’t see or hear of inspections at their markets.</td>
</tr>
<tr>
<td>4 Market managers are concerned that regulatory enforcement is not consistent between jurisdictions and markets within the state.</td>
</tr>
</tbody>
</table>
Table 17: Market manager structured group interview results, Q4 common themes (n=8).

<table>
<thead>
<tr>
<th>Common themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

Table 18: Market manager structured group interview results, Q5 common themes (n=8).

<table>
<thead>
<tr>
<th>Common themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

Table 19: Market manager structured group interview results, Q6 common themes (n=8).

<table>
<thead>
<tr>
<th>Common themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>
Table 20: Market manager structured group interview results, Q9 common themes (n=8).

<table>
<thead>
<tr>
<th>Common themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Some market managers do not like the idea of a flipbook while others see the value of its use in the market setting.</td>
</tr>
<tr>
<td>2. There will have to be an alternative for computer-based training for those vendors who don’t know how or won’t use a computer.</td>
</tr>
<tr>
<td>3. The presentation of the flipbook will be very important to ensuring vendors don’t feel patronized and that the purpose of its use is fulfilled.</td>
</tr>
</tbody>
</table>
Table 21: Summary of questions from needs assessment tools organized by common themes for triangulation analysis.

<table>
<thead>
<tr>
<th>Common Theme/Topic</th>
<th>Farmers’ market vendor observations</th>
<th>PDA health inspector surveys</th>
<th>Farmers’ market vendor surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vendor hygiene and vending area conditions</strong></td>
<td>• Figure 2: “condition and type of vending surface”</td>
<td>• Figure 42-43: Q5a/b “no discharge from eyes, nose, and mouth”</td>
<td>• Figure 28: Q7 “do you clean or sanitize your food stand and/or deli cases with any of the following before each market day?”</td>
</tr>
<tr>
<td></td>
<td>• Figure 3: “condition of vendor clothing”</td>
<td>• Figure 54-55: Q11a/b “food contact surfaces cleaned and sanitized”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Figure 4: “presence of vendor hair coverings”</td>
<td>• Figure 64-65: Q16a/b “personal cleanliness”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Figure 42-43: Q5a/b “no discharge from eyes, nose, and mouth”</td>
<td>• Figure 70-71: Q19a/b “food contact surfaces cleanable, properly designed, and used”</td>
<td></td>
</tr>
<tr>
<td><strong>Disposable glove use</strong></td>
<td>• Figure 5: “disposable glove use”</td>
<td>• Figure 47-48: Q7a/b “no bare hand contact with RTE foods or approved alternative method properly followed”</td>
<td>• Figure 31: Q10 “do you use disposable gloves to handle foods you sell at farmers’ markets?”</td>
</tr>
<tr>
<td></td>
<td>• Figure 6: “behaviors performed without changing gloves among glove users”</td>
<td>• Figure 68-69: Q18a/b “gloves used properly”</td>
<td></td>
</tr>
<tr>
<td><strong>High risk food handling habits and hand washing habits</strong></td>
<td>• Figure 7: “behaviors performed when hand washing was required and not performed among non-glove users”</td>
<td>• Figure 40-41: Q4a/b “Proper eating, tasting, drinking, or tobacco use”</td>
<td>• Figure 32: Q11 “if you do not use disposable gloves at farmers’ markets, do you use another technique to avoid touching foods with your bare hands?”</td>
</tr>
<tr>
<td></td>
<td>• Figure 8: “presence of hand sanitizer in the vending area”</td>
<td>• Figure 44-45: Q6a/b “hands clean and properly washed”</td>
<td>• Figure 33: Q12 “please select the following responses that best describes your hand washing station”</td>
</tr>
<tr>
<td></td>
<td>• Figure 9: “vendor handwashing habits”</td>
<td>• Figure 48-49: Q8a/b “no bare hand contact with RTE foods or approved alternative method properly followed”</td>
<td>• Figure 34: Q13 “please select the following responses that best describe your hand washing habits at the farmers’ market”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Figure 62-63: Q15a/b “Contamination prevented during food preparation, storage, and display”</td>
<td>• Figure 35: Q14 “please select the following responses that best describes when you might wash your hands or use hand sanitizer at the farmers’ market”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Figure 66-67: Q17a/b “in-use utensils; properly stored”</td>
<td>• Figure 36: Q15 “select which behaviors might cause a vendor to accidentally make their food</td>
</tr>
<tr>
<td>Area</td>
<td>Examples</td>
<td>Question</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| Packaging, labeling, and food display      | • Figure 11: “presence of unpackaged foods placed directly onto uncovered vending surfaces”  
• Figure 13: “packaging methods at the farmers’ market” | • Figure 50-51: Q9a/b “food in good condition, safe, and unadulterated”  
• Figure 52-53: Q10a/b “food separated and protected” |
| Cold storage and thermometer use           | • Figure 14: “cold storage of foods which require cold storage”  
• Figure 15: “presence of thermometers in cold storage containers”  
• Figure 16: “types of cold storage used by vendors” | • Figure 24: Q3 “if you sell raw produce, meats, or other raw foods, which foods are pre-packaged before selling them at farmers’ markets?”  
• Figure 25: Q4 “if you sell food items that require cold storage, how do you store them at farmers’ markets?”  
• Figure 26: Q5 “if you sell food items that require cold storage do you use a thermometer at farmers’ markets to check the temperature of the foods?”  
• Figure 27: Q6 “if you use a thermometer at farmers’ markets, how often do you calibrate it?”  
• Figure 36: Q18 “thermometers only have to be calibrated every few months (True/False)”  
• Figure 36: Q19 “after which activity should thermometers be washed, rinsed, and sanitized”  
• Figure 36: Q22 “what temperature should milk, unfrozen raw meat, and unpasteurized apple cider be stored at the farmers’ market” |
| Labeling and certifications                | • Figure 10 “display of food safety training certificates”  
• Figure 20 “presence of vendor contact information on food packaging” | • Figure 60-61: Q14a/b “Food properly labeled; original container”  
• Figure 72-73: Q20a/b “Certification displayed and up-to-date” |
Figure 1: Food products sold by observed vendors at Pennsylvania farmers’ markets (n=42).

Note: Total number of reported food products exceeds number of vendors observed due to individual farmers’ market vendors selling multiple food products.
Figure 2: Direct concealed observation results “condition and type of vending surface” (n=102).

Figure 3: Direct concealed observation results “condition of vendor clothing” (n=102).
Figure 4: Direct concealed observation results “presence of vendor hair coverings” (n=102).

Figure 5: Direct concealed observation results “disposable glove use” (n=102).
Figure 6: Direct concealed observation results “behaviors performed without changing gloves among glove users” (n=23).

* Food refers to unpackaged raw or RTE foods; raw foods included raw poultry, meat, or unwashed eggs; RTE foods were those which met the FDA Food Code definition for RTE; unclean surfaces were those which were not cleaned and sanitized prior to use or un-cleanable.

** Combo refers to observations which included two instances of improper glove use by the same vendor in the same time period of the observation.
Figure 7: Direct concealed observation results “behaviors performed when hand washing was required and not performed among non-glove users” (n=54).

* Food refers to unpackaged raw or RTE foods; raw foods included raw poultry, meat, or unwashed eggs; RTE foods were those which met the FDA Food Code definition for RTE; unclean surfaces were those which were not cleaned and sanitized prior to use or un-cleanable.

** Combo refers to observations which included two instances of improper glove use by the same vendor in the same time period of the observation.
Figure 8: Direct concealed observation results “presence of hand sanitizer in the vending area” (n=102).

Figure 9: Direct concealed observation results “vendor handwashing habits” (n=102).

- Present (n=4)
- Not Present (n=98)

- No Handwashing Observed (n=43)
- No Handwashing Observed After a Behavior Requiring Handwashing (n=54)
- Handwashing Observed After a Behavior Requiring Handwashing (n=5)
Figure 10: Direct concealed observation results “display of food safety training certificates or inspection notices” (n=102).

Figure 11: Direct concealed observation results “presence of unpackaged foods placed directly onto uncovered vending surfaces” (n=102).
Figure 12: Direct concealed observation results “types of foods placed directly onto uncovered vending surfaces” (n=44).

- Produce (n=22)
- Breads (n=1)
- Apples (n=5)
- Raw Mushrooms (n=3)
- Fresh Meat and Poultry on Ice (n=8)
- Fresh Fish (n=5)

Figure 13: Direct concealed observation results “packaging methods at the farmers’ market” (n=102).

- Use Plastic Bag at Time of Sale (n=33)
- Pre-vacuum Packaged (n=7)
- Some Foods Pre-packaged Some Not (n=58)
- Pre-packaged in Other Packaging (n=4)
Figure 14: Direct concealed observation results “cold storage of foods which require cold storage” (n=102).
Note: Instances where no foods sold by vendors required cold storage were labeled as “NA”.

Figure 15: Direct concealed observation results “presence of thermometers in cold storage containers” (n=102).
Note: Instances where no foods sold by vendors required cold storage were labeled as “NA”.
Figure 16: Direct concealed observation results “types of cold storage used by vendors” (n=71).

- Cooler With Ice (n=19)
- On Ice in a Deli-case (n=12)
- Cooler with No Ice (n=7)
- Electric Refrigerator or Freezer (n=29)
- Combo Cooler With Ice and Cooler With No Ice (n=2)
- Combo Refrigerator/Freezer and Deli Case With Ice (n=2)

Figure 17: Direct concealed observation results “vendors offering food samples” (n=102).

- Yes (n=24)
- No (n=78)
Figure 18: Direct concealed observation results “types of foods offered as samples” (n=24).

- Cheese (n=16)
- Milk (n=2)
- Sausage (n=1)
- Hummus (n=3)
- Jam (n=2)

Figure 19: Direct concealed observation results “customer food sample handling method” (n=24).

- Toothpicks (n=16)
- Napkin/Tissue Paper (n=3)
- Bare hands (n=5)
Figure 20: Direct concealed observation results “presence of vendor contact information on food packaging” (n=102).

- Yes (n=37)
- No (n=46)
- Only the Pre-packaged Foods (n=15)
- I can't tell (n=4)

Figure 21: Direct concealed observation results “observations of improper food handling behaviors categorized by packaging method” (n=65).

- Vendors Packaging Foods With a Plastic Bag at Time of Sale (n=24)
- Vendors With Some Pre-Packaged Foods and Some Bagged at Time of Sale (n=37)
- Vendors Only Selling Pre-Packaged Foods (n=4)
Figure 22: Farmers’ market vendor survey results Q1 “what items do you sell at farmers’ markets?” (n=38).

Note: Data reflects multiples responses from each vendor.

Figure 23: Farmers’ market vendor survey results Q2 “what percentage of the items that you sell at farmers’ markets are raised, grown, processed, or made by other processors/farmers?” (n=37).
Figure 24: Farmers’ market vendor survey results Q3 “if you sell raw produce, meats, or other raw foods, which foods are pre-packaged before selling them at farmers’ markets?” (n=31).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 25: Farmers’ market vendor survey results Q4 “if you sell food items that require cold storage, how do you store them at farmers’ markets?” (n=26).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.

Figure 26: Farmers’ market vendor survey results Q5 “if you sell food items that require cold storage do you use a thermometer at farmers’ markets to check the temperature of the foods?” (n=24).

Note: Sum of percent responses may be greater than 100% due to rounding.
Figure 27: Farmers’ market vendor survey results Q6 “if you use a thermometer at farmers’ markets, how often do you calibrate it?” (n=23).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 28: Farmers’ market vendor survey results Q7 “do you clean or sanitize your food stand and/or deli cases with any of the following before each market day?” (n=36).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 29: Farmers’ market vendor survey results Q8 “have you ever been inspected by the PDA or local health department at a farmers’ market or on your farm?” (n=38).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 30: Farmers’ market vendor survey results Q9 “If you offer food samples at farmers’ markets, how are they handled?” (n=36).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 31: Farmers’ market vendor survey results Q10 “do you use disposable gloves to handle foods you sell at farmers’ markets” (n=38).

Note: Sum of percent responses may be greater than 100% due to rounding.
Figure 32: Farmers’ market vendor survey results Q11 “if you do not use disposable gloves at farmers’ markets, do you use another technique to avoid touching foods with your bare hands?” (n=29).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 33: Farmers’ market vendor survey results Q12 “please select the following responses that best describes your hand washing station” (n=35).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 34: Farmers’ market vendor survey results Q13 “please select the following responses that best describe your hand washing habits at the farmers’ market” (n=35).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 35: Farmers’ market vendor survey results Q14 “please select the following responses that best describes when you might wash your hands or use hand sanitizer at the farmers’ market” (n=33).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each vendor.
Figure 36: Farmers’ market vendor survey results, food safety knowledge questions (Q15-Q22).

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15</td>
<td>Select which behaviors might cause a vendor to accidentally make their food items unclean or contaminated with harmful bacteria (Circle all that apply) (n=39)</td>
</tr>
<tr>
<td>Q16</td>
<td>After which activity should a farmers’ market vendor wash his/her hands or change gloves? (Circle all that apply) (n=39)</td>
</tr>
<tr>
<td>Q17</td>
<td>Which is an example of cross-contamination at the farmers’ market? (Circle all that apply) (n=38)</td>
</tr>
<tr>
<td>Q18</td>
<td>Thermometers only have to be calibrated every few months. (n=38)</td>
</tr>
<tr>
<td>Q19</td>
<td>After which activity should thermometers be washed, rinsed, and sanitized? (Circle all that apply) (n=39)</td>
</tr>
<tr>
<td>Q20</td>
<td>Which is a bacteria that is found naturally in the human nose, and can contaminate foods from sneezing, coughing, or someone touching their nose and then touching foods. (Circle all that apply) (n=39)</td>
</tr>
<tr>
<td>Q21</td>
<td>Which of the following can be a source of pathogenic (harmful) bacteria at the farmers market? (Circle all that apply) (n=39)</td>
</tr>
<tr>
<td>Q22</td>
<td>What temperature should milk, unfrozen raw meat, and unpasteurized apple cider be stored at the farmers’ market? (n=38)</td>
</tr>
</tbody>
</table>
Q23 PDA licensing requirements and inspections are important to keep foods sold at farmers’ markets safe. (n=39)
Q24 I have sufficient knowledge in food safety and I don’t need any more training. (n=39)
Q25 I have difficulty putting the food safety knowledge I currently have into practice at the farmers’ market. (n=39)
Q26 I am concerned about pathogenic (harmful) bacteria being in my food products. (n=39)
Q27 I want to learn more about food safety, but I don’t know where or how to get good information. (n=38)
Q28 I am prepared to handle a situation where a food item I sold to a customer makes them sick. (n=39)
Q29 I would focus more on food safety if it helped me sell more products at the farmers’ market. (n=38)
Q30 I would change my food safety practices if I discovered my food products were contaminated with harmful bacteria. (n=38)

Figure 37: Farmers’ market vendor survey results, food safety attitudinal questions (Q23-Q30).
Figure 38: Farmers’ market vendor demographic survey results, Q37 “what is the highest degree or level of school you have completed?” (n=39).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 39: Farmers’ market vendor demographic survey results, Q38 “what is your age” (n=39).

Note: Sum of percent responses may be greater than 100% due to rounding.
Figure 40: PDA public health inspector survey results, Q4a “Proper eating, tasting, drinking, or tobacco use” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 41: PDA public health inspector survey results, Q4b “most common reason(s) for non-compliance (mark all that apply)” (n=39).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 42: PDA public health inspector survey results, Q5a “no discharge from eyes, nose, and mouth” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 43: PDA public health inspector survey results, Q5b “most common reason(s) for non-compliance (mark all that apply)” (n=32).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 44: PDA public health inspector survey results, Q6a “hands clean and properly washed” (n=41).
Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 45: PDA public health inspector survey results, Q6b “most common reason(s) for non-compliance (mark all that apply)” (n=40).
Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 46: PDA public health inspector survey results, Q7a “no bare hand contact with RTE foods or approved alternative method properly followed” (n=43).
Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 47: PDA public health inspector survey results, Q7b “most common reason(s) for non-compliance (mark all that apply)” (n=41)
Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 48: PDA public health inspector survey results, Q8a “adequate hand washing facilities supplied and accessible” (n=43).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 49: PDA public health inspector survey results, Q8b “most common reason(s) for non-compliance (mark all that apply)” (n=41).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 50: PDA public health inspector survey results, Q9a “food in good condition, safe, & unadulterated” (n=44).
Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 51: PDA public health inspector survey results, Q9b “most common reason(s) for non-compliance (mark all that apply)” (n=38).
Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 52: PDA public health inspector survey results, Q10a “food separated and protected” (n=43).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 53: PDA public health inspector survey results, Q10b “most common reason(s) for non-compliance (mark all that apply)” (n=25).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 54: PDA public health inspector survey results, Q11a “food contact surfaces cleaned and sanitized” (n=44).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 55: PDA public health inspector survey results, Q11b “most common reason(s) for non-compliance (mark all that apply)” (n=40).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 56: PDA public health inspector survey results, Q12a “proper cooling methods used and adequate equipment for temperature control” (n=41).
Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 57: PDA public health inspector survey results, Q12b “most common reason(s) for non-compliance (mark all that apply)” (n=36).
Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 58: PDA public health inspector survey results, Q13a “thermometer provided and accurate” (n=40).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 59: PDA public health inspector survey results, Q13b “most common reason(s) for non-compliance (mark all that apply)” (n=39).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 60: PDA public health inspector survey results, Q14a “food properly labeled; original container” (n=40).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 61: PDA public health inspector survey results, Q14b “most common reason(s) for non-compliance (mark all that apply)” (n=37).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 62: PDA public health inspector survey results, Q15a “contamination prevented during food preparation, storage and display” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 63: PDA public health inspector survey results, Q15b “most common reason(s) for non-compliance (mark all that apply)” (n=40).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 64: PDA public health inspector survey results, Q16a “personal cleanliness” (n=43).
Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 65: PDA public health inspector survey results, Q16b “most common reason(s) for non-compliance (mark all that apply)” (n=39).
Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 66: PDA public health inspector survey results, Q17a “in-use utensils; properly stored” (n=43).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 67: PDA public health inspector survey results, Q17b “most common reason(s) for non-compliance (mark all that apply)” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 68: PDA public health inspector survey results, Q18a “gloves used properly” (n=44).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 69: PDA public health inspector survey results, Q18b “most common reason(s) for non-compliance (mark all that apply)” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 70: PDA public health inspector survey results, Q19a “food and non-food contact surfaces cleanable, properly designed, and used” (n=43).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 71: PDA public health inspector survey results, Q19b “most common reason(s) for non-compliance (mark all that apply)” (n=39).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Figure 72: PDA public health inspector survey results, Q20a “certification displayed properly and up-to-date” (n=44).

Note: Sum of percent responses may be greater than 100% due to rounding.

Figure 73: PDA public health inspector survey results, Q20b “most common reason(s) for non-compliance (mark all that apply)” (n=42).

Note: Sum of percent responses may be greater than 100% due to rounding; data reflects multiples responses from each inspector.
Chapter 3

The prevalence and phylogenetic characterization of *Escherichia coli* and hygiene indicator bacteria isolated from leafy green produce, beef, and pork obtained from farmers’ markets in Pennsylvania
Abstract

The popularity of farmers’ markets in the U. S. has led to over 8,200 farmers’ markets in operation in 2014. One result of this success has been a dramatic change in the kinds of foods sold at farmers’ markets. As farmers’ markets have increased in size, scope, and complexity in the kinds of foods sold at these venues, so has the potential food safety risks. Unfortunately, since 2008, seven major foodborne outbreaks and two recalls associated with farmers’ market food products have occurred, causing 80 known reported illnesses and 1 death. Previous studies also have observed some vendors performing high risk food safety retail behaviors at various markets, while other studies identified specific microbiological hazards in foods sold at farmers’ markets. To date, generic E. coli and hygiene indicator organism testing remains a focus of the survey studies performed on farmers’ market food products, however, no study has further characterized E. coli isolates from farmers’ market food products to determine their phylogenetic or potential pathotype designation. In this study, the presence of hygiene indicators (coliforms, fecal coliforms, Listeria spp., E. coli) from kale, lettuce, spinach, beef, and pork obtained from farmers’ markets in Pennsylvania was assessed using the MPN procedure. E. coli isolates also were further characterized for phylogenetic profile and virulence potential.

E. coli was found to be present in 40% (20/50) and 18% (9/50) of beef and pork samples, respectively, and in 28% (15/54), 29% (15/52), and 17% (8/46) of kale, lettuce, and spinach, respectively obtained from Pennsylvania farmers’ markets. The presence of Listeria spp. was observed in 8% (4/50) of beef samples, 2% (1/54) of kale, 4% (2/52) of lettuce, 7% (3/46) of spinach, and 0% found in pork. Among the Listeria spp. isolates, 3/10 were identified as L. monocytogenes. Among E. coli isolated from meat samples, a majority of isolates clustered into phylogroup B1 (66%; 19/29), while produce isolates mainly clustered into phylogroups B2
All of the *E. coli* isolates were found to possess the *fimH* gene (100% 67/67), two beef isolates possessed the ExPEC-associated *iroN* gene, one beef isolate possessed the STEC associated *eae* gene, and two produce isolates were found to possess the ExPEC-associated *hlyD* gene. The presence of *Listeria* spp. and *E. coli* with potential virulence factors found on produce and meat obtained from farmers’ markets in Pennsylvania in this study, are strong indicators that the behaviors and practices of farmers’ market vendors in the retail or farm environment can have a serious impact on the hygienic quality and safety of the foods they produce and sell. These results also suggest that farmers’ market vendors may greatly benefit from food safety training and increased public health oversight.
Introduction

Since the early 1800s, farmers’ markets have continued to facilitate a vital connection between the non-farming populace and the agricultural community (Brown, 2002). Today, the number of farmers’ markets has grown rapidly to over 8,200 in the U. S., increasing over 163% from levels observed just a decade ago, and producing ~$1.2 billion in direct-to-consumer sales annually (USDA, 2014a; USDA, 2014b). One result of this success has been a dramatic change in the kinds of foods sold at farmers’ markets. In fact, the USDA National Farmers’ Market Directory, a database of registered farmers’ markets and types of foods offered, currently lists 28 categories of food products which vendors have reported selling at their respective markets (USDA, 2015b). While fresh produce remains one of the most popular items sold at farmers’ markets, some of the more unique foods offered include: tofu, wild harvested mushrooms, pet food, RTE prepared foods, raw meat and poultry, and seafood (USDA, 2015b). Although the increase in presence of ready-to-eat (RTE) and “Time/Temperature Control for Safety” (TCS) foods at farmers’ markets have helped maintain the popularity of farmers’ markets, many researchers and public health agencies have begun to realize the inherent food safety implications related to the production and sale of these types of foods by vendors with unknown experiences and knowledge in food production and food safety.

Previous studies have begun to reveal the potential food safety risks associated with farmers’ market vendor retail behaviors and the presence of microbiological hazards in foods sold at farmers’ markets. Behnke et al. (2012), reported, that among 18 observed RTE farmers’ market vendors in Indiana, hand washing was observed only twice among 417 instances where it was required. A microbiological comparative study in Pennsylvania identified that 28% and 90% of whole chicken purchased from farmers’ markets (n=100) were positive for Salmonella
spp. and *Campylobacter* spp., respectively, compared to 8% and 52% of poultry purchased at supermarkets (n=100) positive for the same pathogens (Scheinberg et al., 2013). Among lettuce (n=68) sampled from Vancouver farmers’ markets, 13% were found to be positive for *E. coli*, with over half demonstrating resistance to nalidixic acid, ampicillin, kanamycin, or amikacin (Wood et al., 2015). Similarly, *E. coli* was found in 23% and 16% of lettuce (n=128) and spinach (n=59), respectively, sampled from 36 farmers’ markets in Alberta (Bohaychuk et al., 2009). Interestingly, a recent CDC report stated that fresh produce was responsible for 46% of all outbreaks in the U. S. occurring from 1998-2008, with leafy green produce, such as spinach and lettuce, having the highest association with outbreaks, as compared to other produce commodities (Painter et al., 2013).

Unfortunately, the kinds of microbiological hazards identified to be present on foods sampled from farmers’ markets in previous studies also have caused several documented foodborne outbreaks associated with foods sold at North American farmers’ markets. Since 2008, seven major foodborne outbreaks and two recalls have been attributed to foods sold at farmers’ markets, causing 80 known reported illnesses, the kidney failure of a 4 year old girl, and 1 death (Gardner et al., 2011; Anonymous, 2010; Goetz, 2011; Anonymous, 2012; Anonymous, 2013; Anonymous, 2007; Holton, 2014; Siegner, 2015). Pathogens found to be the cause of these outbreaks have included: *Campylobacter* spp., *E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes*. Food contaminated with these pathogens have included: raw bagged peas, fresh strawberries, raw milk, various cheeses, RTE Mexican dishes, and unpasteurized apple cider (Gardner et al., 2011; Anonymous, 2010; Goetz, 2011; Anonymous, 2012; Anonymous, 2013; Anonymous, 2007; Holton, 2014; Siegner, 2015).
To date, generic *E. coli* testing remains a focus of the majority of survey studies performed on various farmers’ market food products, due to its association with potential fecal contamination or unsanitary conditions. However, no study has further characterized those confirmed *E. coli* isolates from farmers’ market food products to determine their phylogenetic status and identify potential virulence genes of interest. Pathogenic *E. coli* causing disease outside of the intestinal tract of humans and animals, known as Extra-intestinal pathogenic *E. coli* (ExPEC), have more recently become a focus of attention, in part, due to evidence of virulence gene acquisition between commensal and ExPEC existing within and outside the human and animal intestinal tract (Goldstone et al., 2014). However, it is unknown whether agricultural products such as meat and produce could be an important environmental reservoir for ExPEC or commensal *E. coli* strains carrying ExPEC associated virulence genes.

Using the recently updated methods by Clermont et al., (2013), *E. coli* also can be organized phylogenetically into 7 groups (A, B1, B2, C, D, E, F), based on the presence of 4 gene targets, *arpA*, *chuA*, *yjaA*, TspE4.C2, or into 5 rare cryptic clades, based on the presence of 2 additional gene targets in *aes* and *chuA* (Clermont et al., 2011). Recent studies have provided evidence that the distribution of *E. coli* clustering into certain phylogroups can be similar among the same host type or in specific gut niches, with certain phylogroups found to be more frequently isolated from humans, versus livestock, plants, wild animals, etc. For instance Dixit et al. (2004) reported that *E. coli* isolated from the porcine duodenum ileum, and colon, grouped into phylogroups A and B, respectively, while only 58% and 24% of phylogroup A and B isolates, respectively, were found in feces. Lescat et al. (2013) collected *E. coli* isolates from French Guiana residents, livestock, and wild animals, and found that phylogroups A and B1 comprised 54% and 24% of human isolates, respectively, while B1, B2, and D made up 52.4%, 10%, and 10%, respectively.
respectively of livestock, and B2 and B1 comprised of 46% and 25% of wild animal isolates, respectively (Lescat et al., 2013). Bailey et al. (2010) also found that E. coli in group A were expressed in 1,889 human stool samples, and Meric et al. (2013) found that the phylogenetic distribution of E. coli isolated (n=106) from salad crops grown in England clustered into phylogroup B1 (48%), with fewer isolates clustering into A (21%), D (15%), B2 (12%), and E (3%). Through this type of phylogenetic and virulence gene characterization, public health officials could gain increased insight into the ecology of E. coli, better identify sources of contamination occurring from farmers’ market food products, and determine whether the presence of E. coli and other bacterial hygiene indicators may pose actual public health risks.

Therefore, the aims of this study are: 1) to evaluate the microbiological quality and safety of produce and meat sold at farmers’ markets in Pennsylvania through the identification of the hygiene indicators (coliforms, fecal coliforms, Listeria spp.) and E. coli present on leafy green produce (kale, lettuce, spinach) and meat (beef, pork) using the most probable number (MPN) procedure; and 2) to further identify the phylogenetic profile and potential ExPEC and Shiga-toxin-producing E. coli (STEC) virulence of isolated E. coli to assess the microbiological risks and identify the unexplored phylogenetic profile of E. coli associated with foods sold at farmers’ markets.

Methods

Identification of farmers’ market vendors in Pennsylvania

Due to the grassroots and local nature of many farmers’ markets, detailed descriptions of farmers’ markets and their associated market managers, vendors, hours of operation, locations, and products offered are not always available or updated via the internet. Therefore, this study utilized multiple sources to identify farmers’ markets throughout Pennsylvania. Farmers’
markets were identified using multiple web sites, advertisements, brochures, and word-of-mouth. Online internet sources included the *Buy Fresh, Buy Local* (http://www.buylocalpa.org/), *Local Harvest* (www.localharvest.com), and the USDA-AMS National Farmers’ Market Directory (http://www.ams.usda.gov/local-food-directories/farmersmarkets).

A sample of 25 farmers’ markets and 58 vendors were selected for the microbiological survey based on their geographic location and the products sold, such as leafy green produce, beef, or pork. Other considerations were the funding available for travel and purchasing of products from select vendors. Selected farmers’ markets were located in the central, eastern, and western areas of Pennsylvania, in major city centers. However, the exact locations will not be reported to protect the confidentiality of farmers’ markets and vendors sampled in this study. Farmers’ markets chosen for this study were located in areas where farmers’ markets were most prevalent and in densely populated regions of Pennsylvania.

*Sample collection*

Leafy green produce (n=50 lettuce, n=50 spinach, n=50 kale) and meat samples (n=50 beef, n=50 pork) were selected for sampling, based on statistical power calculations (0.80 power) using known prevalence rates of *E. coli* in these food products. Beef and pork samples included both frozen and fresh ground beef/pork, roasts, and chops in order to maximize the likelihood of finding those products at farmers’ markets. Sampled meat products also reflected those types of products which were available at each farmers’ market; however, final analyses grouped all meat products into either beef or pork categories. Sampled produce was purchased fresh. Initial sampling was performed during the winter months (October to February) to account for seasonality effects, while the majority of samples were obtained during the summer months (June to August).
During each sampling session, fresh leafy green produce and fresh or frozen meat was purchased from farmers’ markets throughout Pennsylvania. They were aseptically placed into separate sterile plastic bags, stored in rolling transportable coolers containing crushed ice, and transported to the Penn State Muscle Foods Microbiology Laboratory. Upon arrival at the laboratory, produce and meat samples were transferred from coolers and kept refrigerated (4°C) or frozen (-20°C) until analyzed. Fresh produce and meat were analyzed within 24 hours of purchase, while frozen meat samples were kept frozen until analysis (< 3 days). Frozen meats were thawed for approximately 72 hours at 4°C prior to analyses.

Sample preparation

Fresh produce samples were prepared for microbiological analysis following the procedures outlined in the “Enumeration of Escherichia coli and Coliform Bacteria” section of the FDA Bacteriological Analytical Guidebook (FDA-BAM; FDA, 2015). Meat samples were prepared for microbiological analysis following the procedures outlined in the “Most Probable Number Procedure and Tables” section of the USDA Food Safety and Inspection Service Microbiological Laboratory Guidebook (FSIS-MLG; USDA-FSIS, 2015a). Briefly, 25g of each produce or meat sample were aseptically removed from its packaging, placed into filtered sterile stomacher bags (Interscience, Rockland, MA) and mixed with 450 mL of buffered peptone water (BPW). Beef roasts and chops were aseptically cut into 1/2 in cubes prior to stomaching using a sterile knife. Mixed samples were then homogenized for 2 min at 230 rpm in a JumboMix 3500VW stomacher (Interscience). The stomachate was then serially diluted (10^0-10^5) in BPW in preparation for the MPN procedure. The remaining stomachate was used for the BioMerieux Vidas LIS enrichment and testing procedure.
Three Tube-MPN presumptive test for coliforms, fecal coliforms, and E. coli

One (1 mL) of the prepared decimal dilutions of each sample were used to inoculate 9 mL glass tubes containing Durham tubes (VWR International; West Chester, PA) of lauryl tryptose broth (LST; Hardy Diagnostics, Santa Maria, CA) in triplicate for each of the five dilutions ($10^0$-$10^{-5}$). LST tubes were incubated at 35°C for 24 h, and examined for the presence of gas or effervescence, following incubation. Tubes observed negative for gas production were re-incubated for an additional 24 h. To confirm the presence of coliforms, a loopful of positive-gassing LST tubes were transferred to 10 mL tubes of brilliant green bile broth (BGLB; Hardy Diagnostics) and incubated at 35°C for 24 h. BGLB tubes were considered positive for coliforms if gas production or effervescence was observed. To confirm the presence of fecal coliforms and E. coli, a loopful of positive-gassing LST tubes were transferred to tubes containing 10 mL of E. coli broth (EC; Hardy Diagnostics) and incubated at 45.5°C for 24 h-48 h. Tubes negative for gas production were re-incubated for 24 h. EC tubes were considered positive for fecal coliforms if gas production or effervescence was observed. Contents of positive EC tubes were then streak plated onto Levine’s eosin-methylene blue agar (L-EMB; Hardy Diagnostics) and incubated at 35°C for 24 h. Presumptive E. coli colonies appeared dark centered and flat, with or without a metallic sheen. Three presumptive colonies were picked for biochemical confirmation from each plate. Biochemical confirmation consisted of performing a Gram stain (VWR) and IMViC tests (indole test, Voges-Proskauer test, methyl-red test, and citrate test; Hardy Diagnostic). IMViC tests were performed manually with commercially available reagents. Colonies were considered positive for E. coli if they appeared as Gram-negative, non-sporeforming rods and gave IMViC patterns of ++-- (biotype 1) or -+-+ (biotype 2). Biochemically confirmed colonies were transferred to Luria-Bertani broth (LB; Thermo Fisher
Scientific, Waltham, MA) and incubated 35°C for 24 h for further confirmation and analysis. For each positive LST, BGLB, and EC tube, MPN values were calculated following the procedure outlined in “Appendix 2: Most Probable Number from Serial Dilutions” of the FDA-BAM (FDA, 2015). *E. coli* O157:H7 EDL933 and *L. monocytogenes* Scott A were used as positive and negative controls for each test.

*Listeria spp. and *L. monocytogenes* enrichment and confirmation*

Enrichment and confirmation testing for *Listeria spp.* and *L. monocytogenes* was performed using the mini VIDAS compact multiparametric immunoanalyzer and associated materials and protocols (BioMerieux; Hazelwood, MO). To first test for *Listeria* spp., approximately 112.5 mL of stomachate was transferred to 112.5 mL of Fraser broth to produce 225 mL of a half Fraser broth enrichment and incubated at 30°C for 24-26 h in accordance with the VIDAS LIS (*Listeria* spp. test) and LMO2 (*L. monocytogenes* test) protocols (BioMerieux; Hazelwood, MO). One (1 mL) of the incubated enrichment was then transferred to 10 mL of Fraser broth without Ferric Ammonium Citrate (Thermo Fisher Scientific) and incubated at 30°C for 24-26 h. Aliquots (500 mL) of the overnight enrichment were then transferred to the VIDAS LIS reagent strip, heated for 15 min, and inserted into the mini VIDAS apparatus for testing. Enrichments found to be positive for *Listeria* spp., were then tested for *L. monocytogenes* using the LMO2 VIDAS strips and protocols. Samples deemed positive for *Listeria* spp. and *L. monocytogenes* by the mini VIDAS were streak-plated onto Oxford agar and PALCAM agar (Hardy Diagnostic), incubated at 30°C for 24h, and colonies were further confirmed using the Microgen *Listeria* latex agglutination kit (Microgen International, Frederick, MD).
**Virulence gene screening**

In this study, *E. coli* isolates were screened for the presence of virulence genes commonly associated with ExPEC and STEC, to establish their potential virulence and characteristics (Table 1). ExPEC genes chosen for screening are commonly associated with uropathogenic *E. coli* (UPEC), the most commonly isolated ExPEC pathotype, based on research completed by Johnson et al. (2005). Selected ExPEC genes (*P* fimbriae (*papG3*); *S* fimbrial adhesins (*sfa*); Type 1 fimbriae (*fimH*); Catechole siderophore receptor (*ironN*), α-hemolysin (*hlyD*)) were screened using a multiplex PCR assay. In addition, a separate multiplex PCR assay was performed and adapted from Gannon et al. (1993) and Witham et al. (1996) to screen for STEC associated genes (Shiga toxins 1 and 2 (*stx* 1 and *stx* 2); Intimin (*eae*)). Primers and thermocycler conditions are listed in Table 1.

To prepare samples for the PCR assays, biochemically-confirmed *E. coli* isolates were transferred to fresh LB broth and incubated at 35°C for 18-24 h. Samples were vortexed, 400 µl transferred to a sterile microcentrifuge tube, and the sample centrifuged for 2 min at 13,000 x g to harvest cells. Supernatant from centrifuged tubes was discarded and the pellet was resuspended in 150 µl of distilled water. Resuspended samples were then heated to 99°C for 10 min. Heated samples were centrifuged again for 2 min at 13,000 x g to remove debris and the supernatant containing the DNA was stored frozen (-20°C) until further analysis. PCR reactions were performed in 96-well plates (VWR) using the Qiagen Multiplex PCR Master Mix (Qiagen, Venlo, Netherlands). Prior to each multiplex PCR assay, primers (forward and reverse) and reaction mix were prepared following the manufacturer’s instructions. Individual reaction volume totaled 50 µl (25 µl of 2x Qiagen Multiplex PCR Master Mix, 5 µl of 10x primer mix at 2 µM each, 3 µl of <1 µg template DNA, and remaining RNase-free water). Once prepared, 96-
well plates were covered with PCR film and each assay was performed using a Mastercycler pro thermocycler (Eppendorf, Westbury, NY). Positive and negative controls were included with each assay. PCR products were resolved in 1% agarose gel with GreenGlo DNA dye (Denville Scientific, Metuchen, NJ), at 75V for 36 min, with a 100bp DNA ladder viewed under UV light.

**Phylogenetic analysis using the Clermont Method**

The phylogenetic designation of *E. coli* isolates were determined by following the recently updated Clermont *E. coli* phylotyping method (Clermont et al., 2013). Through the described multiplex PCR assay (Table 2), isolates were screened for the combination of the presence of select genes (*chuA*, *yjaA*, TspE4C2, *arpA*, *trpA*). Biochemically-confirmed *E. coli* isolates were prepared for the multiplex assay as described previously. PCR reactions were performed in 96-well plates (VWR) with a total reaction volume of 20 µl. PCR reaction components were obtained from New England Biolabs, Ipswich, MA (NEB), and each reaction consisted of 2 µl of 10x standard *Taq* reaction buffer, 0.25 µl of dNTPs, 1 µl of each 20 µM primer pair, 0.5 µl of 2.5 U *Taq* polymerase, and 4.25 µl of dH2O. Once prepared, 96-well plates were covered with PCR film and each assay was performed using a Bio-Rad C1000 Touch Thermal Cycler (Bio-Rad Hercules, CA). *E. coli* C600 and the *trpA* internal primer controls were used as controls for each assay (Table 2). PCR products were resolved in 1% agarose gel with SYBR safe dye (Thermo Fisher Scientific), at 75V for 36 min with a 100bp DNA ladder viewed under UV light. Phylotype was determined based on the combination of the presence of each gene target using the decision tree provided by (Clermont et al. 2013) (Table 3).
Results

Prevalence and concentrations of hygiene indicators, E. coli, and Listeria spp. in produce and meat samples purchased from farmers’ markets in PA

Through the use of the MPN enrichment methods, the prevalence and estimated concentrations of coliforms, fecal coliforms, and E. coli were determined (Table 4). Among meat samples, E. coli was found to be present in 40% (20/50) and 18% (9/50) of beef and pork samples, respectively, with an overall meat sample prevalence of 29% (29/100). Among produce samples, 28% (15/54), 29% (15/52), and 17% (8/46) of kale, lettuce, and spinach, respectively, were identified as positive for E. coli, with an overall produce prevalence of 23% (38/152). Concentrations of coliforms, fecal coliforms, and E. coli were found to vary widely between samples, and therefore the geometric mean was used in an effort to normalize estimated mean concentrations. Estimated average coliform counts among all meat and produce samples were found to be relatively low (<60 MPN/g); however, individual samples ranged from (0-1100 MPN/g). The same result was observed among average fecal coliform and E. coli counts among all samples, with average concentrations of (<5 MPN/g) of individual samples ranging from (0-1100 MPN/g) for both E. coli and fecal coliforms.

The presence of Listeria spp. was observed in 8% (4/50) of beef samples, 2% (1/54) of kale, 4% (2/52) of lettuce, 7% (3/46) of spinach, and 0% found in pork. Among the Listeria spp. isolates, 3/10 were identified as L. monocytogenes, which originated from 2/4 beef and 1/3 spinach samples positive for Listeria spp.

Differences among estimated average bacterial counts also were observed between summer and winter months (Table 5). In fact, 0% of produce and pork samples were found to harbor any fecal coliforms, E. coli, or Listeria spp. during winter months. However sample sizes
in the winter months were much lower than the summer sampling. Alternatively, beef samples showed little differences in estimated average bacterial counts between seasons.

*Phylogenetic characterization and presence of virulence genes associated with ExPEC and STEC isolated from produce and meat samples purchased from farmers’ markets in PA.*

Through the use of the Clermont *E. coli* phylotyping method, the distribution of *E. coli* phylogenotypes among beef and produce samples obtained from farmers’ markets in PA were determined (Figure 1). Among *E. coli* isolated from meat samples, a majority of isolates grouped into B1 (66%; 19/29), with the remaining isolates distributed among phylogroups A (7%; 2/29), B2 (7%; 2/29), C (3%; 1/29), E (0%), Clade I/II (3%; 1/29), and unknown 14% (4/29). To determine phylotypic lineage of unknown isolates further MLST analysis would be required using the Pasteur Institute MLST scheme (Clermont et al., 2011). *E. coli* isolated from produce samples were distributed among more phylogroups, with the majority grouping into phylogroups B2 (36%; 14/39) and B1 (33%; 13/39). The remaining *E. coli* isolated from produce were distributed into phylogroups A (5%; 2/39), C (3% 1/39), E (10%; 4/39), Clade I/II (5%; 2/39), and unknown 5% (2/39).

ExPEC and STEC multiplex PCR analysis also revealed the presence of select genes in *E. coli* isolated from beef and produce samples obtained from farmers’ markets in PA (Table 6). Interestingly, 100% of *E. coli* isolates found in both meat and produce samples were identified as possessing the *fimH* gene, which encodes for a type 1-fimbrial adhesion protein. Two separate beef samples also were found to possess the ExPEC associated *iroN* gene or the STEC associated *eae* gene, encoding for a catecholate siderophore receptor and the intimin adhesion protein, respectively. Among produce samples, two *E. coli* isolated from kale and lettuce were found to possess the ExPEC-associated *hlyD* gene encoding for α-hemolysin protein. Only 3 *E. coli* isolates were found to possess more than one virulence gene, and no isolates possessed more
than two ExPEC or STEC-associated virulence genes. *E. coli* possessing *eae*, *hlyD*, or *iroN*, were found to group into either B1 (*eae*, *hlyD*) or B2 (*hlyD*, *iroN*).

**Discussion**

*Prevalence of hygiene indicators, E. coli, and Listeria spp. in leafy green produce obtained from farmers’ markets in Pennsylvania.*

To date, few studies have evaluated the microbiological quality and safety of farmers’ market food products through microbiological sampling, testing, and analysis. Furthermore, hygiene indicators, such as *E. coli* isolated during such studies, have not been characterized further. As farmers’ markets continue to increase in number and product complexity, identifying the unique risks associated with foods sold at farmers’ markets is key to developing strategies to mitigate those risks, while protecting public health and ensuring the continued success of farmers’ markets in the U. S.

In this study, the prevalence of hygiene indicators (coliforms, fecal coliforms, *E. coli*, and *Listeria* spp.) were identified to evaluate the microbiological quality and safety of fresh produce and meat products obtained from Pennsylvania farmers’ markets. Although current U. S. federal food safety regulations do not enforce limits for hygiene indicators on fresh produce, such as *E. coli* and *Listeria* spp., the presence of these organisms is considered a sign of poor hygienic quality, leading to potential food safety risks. Furthermore, surveys of retail produce, specifically testing for pathogenic *E. coli*, rather than generic *E. coli*, have resulted in few confirmed positive isolates, revealing little about the overall hygienic quality and characteristics of pathogenic bacteria existing in those food products. In fact, results from the USDA Agricultural Marketing Service (AMS) Microbiological Data Program reported in 2011, that only 5/2336 (0.2%) of lettuce and 29/2328 (1.2%) of spinach sampled in 2009, from produce
distribution and processing centers throughout the U. S., were positive for pathogenic *E. coli* (USDA-AMS, 2011).

The results of this study revealed a notable prevalence of *E. coli* with a low prevalence of *Listeria* spp. and *L. monocytogenes* present on leafy green produce, comparable to other known survey studies of retail produce. For instance, Mukherjee et al. (2006) collected organic, semi-organic, and conventional produce from 24 farms in Minnesota and Wisconsin and found that 15% and 16% of sampled leafy greens (n=296) and lettuces (n=157) were *E. coli* positive. Similarly, Bohaychuk et al. (2009) sampled fresh produce sold at 36 farmers’ markets in Alberta, Canada, and found an *E. coli* prevalence rate of 23% and 16% in lettuce (n=128) and spinach (n=59), respectively. In contrast, known survey studies of fresh and bagged produce focused on *Listeria* spp. and *L. monocytogenes* isolation have generally revealed low prevalence rates (<5%) of both *Listeria* spp. and *L. monocytogenes* (Thunberg et al., 2002; Samadpour et al., 2006; Luchansky et al., 2012).

Overall, results of produce sampled in previous studies have revealed lower prevalence rates of *E. coli* and similar prevalence of *Listeria* spp. and *L. monocytogenes*, as compared to the results of this study. The higher *E. coli* prevalence reported in this study could be a result of a greater recovery of *E. coli* due to the use of the MPN multi-step enrichment procedure. However, the results may also reflect variable farming and retail conditions unique to produce sold at farmers’ markets in Pennsylvania. It is also important to note, however, that average estimated *E. coli* concentrations among all produce sampled in this study were <5 MPN/g, although individual samples ranged as low as 0 MPN/g and as high as 1100 MPN/g. These data suggest that *E. coli* contamination in leafy green produce obtained from farmers’ markets in this study, appears to be sporadic and vendor-dependent. This observation is further supported by the
fact that produce obtained from 31% (18/58) of the farmer’s market vendors sampled were responsible for 100% of the E. coli contamination found in this study (Appendix F). Overall, the sporadic prevalence and wide range of concentrations of E. coli found in leafy green produce obtained from farmers’ markets in PA does suggest that improper vendor retail behaviors or unhygienic farming practices may result in E. coli contamination and therefore, poor produce quality and safety. Furthermore, while the presence of Listeria spp. and L. monocytogenes on produce obtained in this study also is of concern, the infrequent occurrence further supports the conclusion that a majority of farmers’ market vendors may be utilizing proper hygienic practices, both at retail and at the farm, while the unhygienic behaviors and practices of few vendors results in sporadic produce contamination.

Prevalence of hygiene indicators, E. coli, and Listeria spp. in beef and pork products obtained from farmers’ markets in Pennsylvania.

In the U. S., no legal regulatory standards exist for the presence of generic E. coli in beef, pork, and other meat products. However, the USDA-Food Safety Inspection Service (FSIS) does encourage the use of E. coli testing in slaughter and processing facilities as a method of process control and verification of HACCP (Hazard Analysis and Critical Control Point) systems used to mitigate food safety risks in the establishment. The USDA-FSIS also utilizes a series of performance standards for generic E. coli testing for beef and swine carcasses, which state that excision sampling of carcasses revealing E. coli concentrations above 100 CFU/cm² and 10,000 CFU/cm² in beef and swine, respectively, are considered unacceptable and would require corrective actions to regain process controls (USDA-FSIS, 2015b). To our knowledge, the USDA-FSIS does not provide or enforce generic E. coli testing performance standards for intact and non-intact beef and pork products, due to the focus on pathogen testing. Nevertheless, like
produce, the presence of hygiene indicators on raw meat products may indicate poor sanitation practices, unhygienic conditions, or potential fecal contamination occurring during slaughter.

In this study, the 40% and 18% prevalence rates of *E. coli* found on raw beef and pork products, respectively, and the presence of *Listeria* spp. and *L. monocytogenes* found on beef products, is a clear indication that unhygienic conditions exist during slaughter, further processing, and/or retail conditions related to meat products obtained from farmers’ markets in PA. While the average *E. coli* concentration found in all meat products sampled in this study was <5 MPN/g, individual samples ranged from 0 MPN/g to 250 MPN/g. Unlike leafy green produce, which is generally consumed raw, *E. coli* found on raw meat products would be effectively eliminated with proper cooking. In contrast to produce, all beef and pork products sold in the U. S., including at farmers’ markets, must originate from USDA-FSIS inspected slaughter and processing facilities, although retail exemptions do exist. USDA-FSIS retail exemptions allow for the further processing of inspected meat for sale at retail outlets, such as butcher shops, delis, and possibly farmers’ markets that may not receive USDA-FSIS inspection. However, the retail exemption status of vendors sampled in this study was not established, and therefore, it is unknown whether contamination may have originated from USDA-FSIS-inspected facilities or from conditions in retail exempt processing areas.

Interestingly, a high prevalence of *E. coli* in beef and pork sampled from retail outlets has been observed before. Between 2002 and 2008, Zhao et al. (2012) isolated *E. coli* from 69% of ground beef samples (n=2,991) and 44% of pork chop samples (n=3,000) obtained from supermarkets in several U. S. states. In a related study, Magwedere et al. (2013) reported that among ground beef and pork samples obtained from Pennsylvania and Virginia supermarkets, 35% and 50% of ground beef and pork were positive for STEC-related O-groups, although no
samples were positive for Shiga toxin genes. Similarly, Svoboda et al. (2013), found that among 118 samples of ground beef sampled from processing plants and retail stores in Pennsylvania, ~18% were positive for STEC-related O-groups; however, no samples were positive for Shiga toxin-producing genes. These results suggest that while STEC control in the meat industry appears to be successful, non-STEC are still persisting through processing and can be isolated from meat products at retail.

*Phylogenetic characterization and presence of ExPEC and STEC related virulence genes in E. coli isolated from produce and meat samples purchased from farmers’ markets in Pennsylvania.*

Recent research focused on the role of *E. coli* existing within and outside of the intestinal tract of animals and humans has led to a renewed focus on the ecological and evolutionary significance of ExPEC. Research has continued to further identify key virulence genes associated with ExPEC, and the importance of those genes in various environments (Belanger et al., 2011; Spurbeck et al., 2012; Ahmed et al., 2011; Johnson and Russo, 2002). There also is increasing evidence that the distribution of specific *E. coli* phylogroups may have important associations with commensal gut niches or specific hosts.

In this study, the phylogenetic distribution of *E. coli*, isolated from leafy green produce and meat products obtained from farmers’ markets in PA, appears to coincide with previously reported data. A majority (66%) of *E. coli* isolated from farmers’ market beef and pork products clustered into phylogroup B1. In contrast, the majority of *E. coli* isolated from farmers’ market produce clustered into two phylogroups; B1 (33%) and B2 (36%). Only a small percentage of *E. coli* isolated from both meat (7%) and produce (5%) clustered into phylogroup A. The remaining *E. coli* isolated from meat and produce were found to cluster into C, E, Clade I/II, or were unidentifiable without the use of MLST. While the absence of *E. coli* originating from farmers’ market meat and produce which clustered into phylogroup A, could suggest that the observed *E.
coli contamination did not originate from human sources, more research is needed to demonstrate this association. Likewise, the high percentage of E. coli isolated from meat products which grouped into B1 in this study, is in agreement with previous results which demonstrated that E. coli isolated from livestock sources commonly cluster into phylogroup B1. To our knowledge, these results are the first to describe the phylogenetic profile of E. coli isolated from produce and meat sold at retail, and more specifically, from farmers’ markets in the U.S.

To date, limited to no data are available to describe the prevalence of ExPEC- or STEC-related virulence genes in both fresh retail produce or meat products. Nevertheless, the results of this study revealed that a small portion of E. coli isolated from farmers’ market produce and beef possessed two ExPEC-related virulence genes, while 100% of E. coli isolates possessed fimH. It is important to note that proper cooking of contaminated raw beef samples would eliminate the E. coli possessing those virulence genes. However, produce consumed raw and contaminated with E. coli possessing virulence genes, may pose a significant health risk. While it is well established that fimH plays a critical role in the pathogenesis of UPEC, its presence has been found to be common among commensal strains of E. coli and other bacteria found in the environment (Connell et al., 1996; Sokurenko et al., 1998).

For instance, Nowrouzian et al. (2004), reported that fimH was found in ~93% of 149 commensal E. coli strains isolated from healthy newborn’s stool. Holden et al. (2013) also reported that fimH was detected in 100% of E. coli originating from barley and associated soil, which was not fertilized with animal manure. Additionally, soil bacteria (Actinobobacteria, Firmicutes, Gammaproteobacteria) isolated from beech wood soil in Denmark were found to possess fimH (Soborg et al., 2014). It has been hypothesized that fimH could provide bacteria existing in abiotic environments, with the ability to infect invertebrates; however, this observation has yet to be
proven (Soborg et al., 2014). While the presence of fimH has been associated with ExPEC virulence, research also has demonstrated that only specific mutations within the fimH subunit of the fim gene cluster confers virulence leading to UPEC infections (Connell et al., 1996; Sabate et al., 2006). The presence of fimH in E. coli isolated from farmers’ market produce and meat in this study could be indicative of E. coli existing in abiotic environments, although more research is needed to support this association. Nevertheless, the presence of fimH and hlyD in E. coli isolated from farmers’ market produce is an important finding, since hlyD has been shown to produce phenotypic hemolysis among pathogenic ExPEC strains (Ejrnaes et al. 2011).

As was discussed recently by Wassenaar and Gunzer, (2015), determining whether an E. coli strain is pathogenic is not always clear cut, and the distinction between a commensal and pathogen is a gray area, especially among ExPEC strains. Recent studies have demonstrated that the presence of specific virulence factors does not always predict a virulent phenotype (Wassenaar and Gunzer, 2015; Merhej et al., 2013). For the purposes of this study, the presence of E. coli with potential virulence factors found in farmers’ market meat and produce is another indication of poor hygienic quality and safety, but may not be indicative of a source of ExPEC or STEC.

Conclusions

Ensuring the safety of fresh produce and raw meat products sold at farmers’ markets is not only vital for safeguarding public health, but also for supporting the ongoing efforts to promote and sustain the production and sale of locally-grown agricultural products. With careful oversight and further knowledge of the risks associated with foods sold at farmers’ markets, food safety risks can be mitigated. The results of this study demonstrate that the behaviors and practices of farmers’ market vendors, either in the retail or farm environment, may have a significant impact on the hygienic quality and safety of the foods they produce and sell at farmers’ markets. The high
prevalence of *E. coli* with potential ExPEC and STEC virulence factors, found on both produce and meat products obtained from farmers’ markets in this study, are strong indicators that farmers’ market vendors would benefit greatly from food safety training and increased public health oversight. However more samples and *E. coli* isolates are needed to arrive at more concrete conclusions. The results of this study may be useful for public health regulators and food safety educators in the U. S.
References


Table 1: Multiplex PCR conditions, primer sequences, and target genes for ExPEC and STEC assays.

<table>
<thead>
<tr>
<th>Genes</th>
<th>PCR Reaction</th>
<th>Primer Sequence (3’-5’)</th>
<th>Size of amplicon</th>
<th>PCR conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>papG3</td>
<td>ExPEC Multiplex Screen *</td>
<td>F-GGCCCTGCAATGGAATTACCTGG R-CCACCAAATGACCATGCCGAC</td>
<td>258 bp</td>
<td>Activation 95°C 12 min (1 cycle)</td>
</tr>
<tr>
<td>sfa</td>
<td>ExPEC Multiplex Screen *</td>
<td>F-CTCCGAGAAGTGGGATCTCTTAC R-CGGAGGAGTAGTATACAAACCTGGCA</td>
<td>410 bp</td>
<td>Denaturation 94°C 30 sec (25 cycles)</td>
</tr>
<tr>
<td>fimH</td>
<td></td>
<td>F-TGAGAAGCAGTGGGATCTCTTAC R-GACGTCACTGCCCCTGCCGTA</td>
<td>508 bp</td>
<td>Annealing 63°C 30 sec</td>
</tr>
<tr>
<td>iroN</td>
<td></td>
<td>F-AAAGTAAGACGGGGTTGCCC</td>
<td>667 bp</td>
<td>Extension 68°C 3 min</td>
</tr>
<tr>
<td>hlyD</td>
<td></td>
<td>F-CTCCGACCTGAAAGGAC</td>
<td>904 bp</td>
<td>Final Extension 72°C 10 min (1 cycle)</td>
</tr>
<tr>
<td>eae</td>
<td>STEC Multiplex Screen **</td>
<td>F-GTGGCGAAACTGGCCAGACT R-CCGATTCCTTCTTCACCATGGTGG</td>
<td>890 bp</td>
<td>Activation 94°C 15 min (25 cycles)</td>
</tr>
<tr>
<td>stx-1</td>
<td></td>
<td>F-CCATGCAACGGACAGCACTTTT</td>
<td>779 bp</td>
<td>Denaturation 94°C 30 sec</td>
</tr>
<tr>
<td>stx-2</td>
<td></td>
<td>F-ACACTGGATGATCCTCAGTGG R-CTGATCCCTCCATATTAG</td>
<td>614 bp</td>
<td>Annealing 59°C 90 sec</td>
</tr>
</tbody>
</table>

* Primer sequences and gene targets adapted from (Johnson et al., 2005). The selection of genes was based on prevalence data of the genes in a large number of ExPEC strains.

** Primer sequences and gene targets adapted from (Gannon et al., 1993; Witham et al., 1996).
Table 2: PCR conditions, primer sequences, and gene targets for the Clermont *E. coli* phylotyping method (Clermont et al. 2013).

<table>
<thead>
<tr>
<th>Genes</th>
<th>PCR Reaction</th>
<th>Primer Sequence (3’-5’)</th>
<th>Primer Target</th>
<th>PCR conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>chuA.1b</td>
<td>Quadruplex (Initial screen)</td>
<td>F-ATGGTACCAGCAAGACAAAC&lt;br&gt;R-TGCCGCTGACTACAAAGACA</td>
<td>288 bp</td>
<td>(1 cycle)&lt;br&gt;Activation 94°C 4 min&lt;br&gt;(30 cycles)&lt;br&gt;Denaturation 94°C 5 sec&lt;br&gt;Annealing 59°C 20 sec&lt;br&gt;Final Ext 72°C 10 min</td>
</tr>
<tr>
<td>chuA.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yjaA.1b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yjaA.2b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TspE4C2.1b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TspE4C2.2b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AceK.f</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ArpA1.r</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ArpAgpE.f</td>
<td>Group E</td>
<td>F-GATTCCATCTTTGCTAAAAATAGCC&lt;br&gt;R-GAAAAAGAAAAAGAATCCCAAAGAG</td>
<td>301 bp</td>
<td></td>
</tr>
<tr>
<td>ArpAgpE.r</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trpAgpC.1</td>
<td>Group C</td>
<td>F-AGTTTTATGCCCAGTGCGAG&lt;br&gt;R-TCTGCGCCGCAGTCACGCC</td>
<td>219 bp</td>
<td></td>
</tr>
<tr>
<td>trpAgpC.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trpBA.f</td>
<td>Internal Control</td>
<td>F-CGCGGATAAGACATCTTCAC&lt;br&gt;R-GCAAAGCGGCTGCGGGAAG</td>
<td>489 bp</td>
<td></td>
</tr>
<tr>
<td>trpBA.r</td>
<td></td>
<td></td>
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<td></td>
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Table 3: *E. coli* phylotyping and assigning of *E. coli* to phylogroups (Clermont et al. 2013).

<table>
<thead>
<tr>
<th>arpa</th>
<th>chuA</th>
<th>yjaA</th>
<th>TspE4.C2</th>
<th>Phylogroup</th>
<th>Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>B2</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>B2</td>
<td>Could be confirmed by testing <em>IbeA</em> gene</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>A or C</td>
<td>Screen using C-specific primers. If C+ then C, else A</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>D or E</td>
<td>Screen using E-specific primers. If E+ then E, else D</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>D or E</td>
<td>Screen using E-specific primers. If E+ then E, else D</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>E or Clade I</td>
<td>Screen using E-specific primers. If E- then Clade I, confirm using cryptic clade primers</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Clade I or Clade II</td>
<td>Confirm using cryptic clade primers</td>
</tr>
<tr>
<td>-</td>
<td>467bp*</td>
<td>-</td>
<td>-</td>
<td>Clade III, IV, or V</td>
<td>Confirm using cryptic clade primers</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>Unknown</td>
<td>Perform MLST</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>Unknown</td>
<td>Perform MLST</td>
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<td>+</td>
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<td>+</td>
<td>Unknown</td>
<td>Perform MLST</td>
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<tr>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>Unknown</td>
<td>Perform MLST</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Unknown</td>
<td>Perform MLST</td>
</tr>
</tbody>
</table>

* Strains belonging to cryptic clade III, IV or V may yield a 476 bp PCR product. If this outcome occurs, then such strains should be screened using the cryptic clade detection primers (Clermont et al., 2011).
Table 4: Prevalence, geometric mean, and range MPN/g concentrations of coliforms, fecal coliforms, and *E. coli* in meat and produce purchased from farmers’ markets in PA.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Coliforms Mean (Range) MPN/g</th>
<th>Fecal Coliforms Mean (Range) MPN/g</th>
<th><em>E. coli</em> Mean (Range) MPN/g</th>
<th><em>E. coli</em> Mean (Range) among positive samples MPN/g</th>
<th><em>E. coli</em> Prevalence</th>
<th>Listeria spp. Prevalence</th>
<th>L. monocytogenes Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (n=50)</td>
<td>29 (0-1100)</td>
<td>2.3 (0-240)</td>
<td>2 (0-240)</td>
<td>7 (0-240)</td>
<td>40% (20/50)</td>
<td>8% (4/50)</td>
<td>4% (2/50)</td>
</tr>
<tr>
<td>Pork (n=50)</td>
<td>3 (0-460)</td>
<td>2 (0-240)</td>
<td>1 (0-240)</td>
<td>8 (0-240)</td>
<td>18% (9/50)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Kale (n=54)</td>
<td>58 (0-1100)</td>
<td>5 (0-460)</td>
<td>2 (0-240)</td>
<td>9 (0-240)</td>
<td>28% (15/54)</td>
<td>2% (1/54)</td>
<td>0%</td>
</tr>
<tr>
<td>Lettuce (n=52)</td>
<td>48 (0-1100)</td>
<td>5 (0-1100)</td>
<td>2 (0-1100)</td>
<td>13 (0-1100)</td>
<td>29% (15/52)</td>
<td>4% (2/52)</td>
<td>0%</td>
</tr>
<tr>
<td>Spinach (n=46)</td>
<td>36 (0-1100)</td>
<td>4 (0-1100)</td>
<td>2 (0-1100)</td>
<td>116 (0-1100)</td>
<td>17% (8/46)</td>
<td>7% (3/46)</td>
<td>2% (1/46)</td>
</tr>
<tr>
<td>Total Meat (n=100)</td>
<td>9 (0-1100)</td>
<td>2 (0-240)</td>
<td>2 (0-240)</td>
<td>8 (0-240)</td>
<td>29% (29/100)</td>
<td>4% (4/100)</td>
<td>2% (2/100)</td>
</tr>
<tr>
<td>Total Produce (n=152)</td>
<td>47 (0-1100)</td>
<td>4 (0-1100)</td>
<td>3 (0-1100)</td>
<td>17 (0-1100)</td>
<td>25% (38/152)</td>
<td>4% (6/152)</td>
<td>0.7% (1/152)</td>
</tr>
</tbody>
</table>
Table 5: Prevalence, geometric mean, and range MPN concentration of coliforms, fecal coliforms, and *E. coli* in meat and produce purchased from farmers’ markets in PA during summer (S) and winter (W) months.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Coliforms Mean (Range) MPN/g</th>
<th>Fecal Coliforms Mean (Range) MPN/g</th>
<th><em>E. coli</em> Mean (Range) MPN/g</th>
<th>Concentration among Positive <em>E. coli</em> Samples Mean (Range) MPN/g</th>
<th>E. coli Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef (n=6)</td>
<td>31 (0-1100)</td>
<td>2 (0-9)</td>
<td>7 (0-9)</td>
<td>7 (0-9)</td>
<td>38% (6/16)</td>
</tr>
<tr>
<td>Pork (n=9)</td>
<td>1 (0-3.6)</td>
<td>0 (0-240)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Kale (n=10)</td>
<td>5 (0-240)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Lettuce (n=10)</td>
<td>4 (0-240)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Spinach (n=11)</td>
<td>20 (0-1100)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total Meat</strong></td>
<td>11 (0-1100)</td>
<td>2 (0-240)</td>
<td>2</td>
<td>7</td>
<td>24% (6/25)</td>
</tr>
<tr>
<td><strong>Produce</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kale (n=10)</td>
<td>5 (0-240)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Lettuce (n=10)</td>
<td>4 (0-240)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Spinach (n=11)</td>
<td>20 (0-1100)</td>
<td>0 (0-1100)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total Produce</strong></td>
<td>7 (0-1100)</td>
<td>6 (0-1100)</td>
<td>3</td>
<td>19</td>
<td>31% (38/121)</td>
</tr>
</tbody>
</table>
Table 6: Prevalence of select ExPEC and STEC virulence genes among *E. coli* isolated from meat and produce purchased from farmers’ markets in PA.

<table>
<thead>
<tr>
<th>Samples</th>
<th>fimh</th>
<th>iroN</th>
<th>hlyD</th>
<th>sfa</th>
<th>papG3</th>
<th>eae</th>
<th>stx1</th>
<th>stx2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (n=20)</td>
<td>100% (20/20)</td>
<td>5% (1/20)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>5% (1/20)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Pork (n=9)</td>
<td>100% (9/9)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Kale (n=15)</td>
<td>100% (15/15)</td>
<td>0%</td>
<td>7% (1/15)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lettuce (n=15)</td>
<td>100% (15/15)</td>
<td>0%</td>
<td>7% (1/15)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Spinach (n=8)</td>
<td>100% (8/8)</td>
<td>13% (1/8)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total Meat (n=29)</td>
<td>100% (29/29)</td>
<td>3% (1/29)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3% (1/29)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total Produce (n=38)</td>
<td>100% (38/38)</td>
<td>3% (1/38)</td>
<td>5% (2/38)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Figure 1: Phylogenetic distribution of *E. coli* isolated from meat and produce purchased from farmers’ markets in PA. Note: No (0%) isolates were found to group into phylogroups D, F, or Clades III-V.

<table>
<thead>
<tr>
<th>Samples</th>
<th>A</th>
<th>B1</th>
<th>B2</th>
<th>C</th>
<th>E</th>
<th>Clade 1/II</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (n=20)</td>
<td>2</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Pork (n=9)</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Kale (n=15)</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lettuce (n=15)</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Spinach (n=8)</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Meat (n=29)</td>
<td>7% (2/29)</td>
<td>66% (19/29)</td>
<td>7% (2/29)</td>
<td>3% (1/29)</td>
<td>0</td>
<td>3% (1/29)</td>
<td>14% (4/29)</td>
</tr>
<tr>
<td>Total Produce (n=38)</td>
<td>5% (2/38)</td>
<td>34% (13/38)</td>
<td>36% (14/38)</td>
<td>3% (1/38)</td>
<td>10% (4/38)</td>
<td>5% (2/38)</td>
<td>5% (2/38)</td>
</tr>
</tbody>
</table>
Chapter 4

The development and pilot test of a face-to-face food safety training program for farmers’ market vendors in Pennsylvania
Abstract

In many U. S. states and across North America, the farmers’ market movement is thriving. In fact, the number of farmers’ markets in the U. S. has increased to over 8,200, resulting in ~$1.3 billion in direct to consumer sales in 2012. Despite the benefits that farmers’ markets provide, many researchers and public health agencies have begun to realize the inherent food safety risks associated with the production and sale of this relatively unregulated food industry. In most U. S. states, farmers’ market vendors and their food products are not inspected by public health inspectors; therefore, the quality and safety of those foods are relatively unknown. Recent studies also have revealed poor farmers’ market vendor knowledge and proper food safety practices on the farm and at the farmers’ market. While these studies have revealed concerning food safety risks, these gaps could be effectively addressed through educational programming and training. Research has shown that effective food safety training increases food safety-related knowledge and attitudes, while improving skills and behaviors of retail food operation employees. However, due to the unique conditions in which farmers’ market vendors produce, store, transport, and sell their products, commonly used retail food safety training programs may not be suitable to address the unique issues related to farmers’ market food safety.

Therefore, based on the results collected previously through a comprehensive needs assessment performed on farmers’ market vendors in Pennsylvania, the purpose of this study was to develop and pilot-test a customized, retail food safety training program for farmers’ market vendors. A practical and customized 3-hour, in-person, training program consisting of interactive PowerPoint presentations and the use of a comprehensive reference guide was developed and pilot tested in Pennsylvania. Using pre- and post-test assessment tests conducted during the pilot training sessions, the results found participants scores on knowledge questions
increased significantly by ~20% (p<0.05) with positive increases in attitudes related to retail food safety topics. The results of the pilot study demonstrated that a combination of a comprehensive training resource guide with interactive slide presentation training methods, could result in significant gains in farmers’ market vendor knowledge and change in attitudes among farmers’ market vendor participants.
**Introduction**

In many U. S. states and across North America, the farmers’ market movement is thriving. The sale of locally grown agricultural products from the farmer or producer direct to consumers, known as direct-to-consumer marketing, has become commonplace and extremely popular. In fact, the number of farmers’ markets in the U. S. has increased to over 8,200, resulting in ~$1.3 billion in direct to consumer sales in 2012 (USDA, 2014). While direct-to-consumer sales still account for less than 1% of total agricultural sales in the U. S., the impact is significant for the 144,530 farms which participated in direct-to-consumer marketing in 2012, in addition to the millions of consumers who purchased and consumed their agricultural products (USDA, 2014). There is no doubt that the success of farmers’ markets provides important economic and nutritional benefits for farmers and consumers. Despite these benefits, many researchers and public health agencies have begun to realize the inherent food safety risks associated with the production and sale of this relatively unregulated food industry.

In most U. S. states, farmers’ market vendors and their food products are not inspected by local, state, of federal public health inspectors; therefore, the quality and safety of foods sold at farmers’ markets is relatively unknown. Due to the lack of regulatory oversight, farmers’ market vendors also are generally uncertified or untrained in proper food processing methods and retail food safety processes and procedures. Recent studies have revealed poor farmers’ market vendor knowledge and proper food safety practices on the farm and at the farmers’ market. For instance, researchers in Ontario, Canada observed 17 farmers’ market cheese vendors and reported 47% were not properly refrigerating cheese, 88% did not wash their hands before or after handling cheese, and 24% stored cheese next to raw foods such as meat (Teng et al., 2004). Similarly, Behnke et al. (2012), reported, that among 18 observed RTE farmers’ market vendors
in Indiana, hand washing was observed only twice among 417 instances where it was required. A knowledge, attitudes, and behavior survey performed in Pennsylvania among 21 farmers’ market poultry vendors revealed that 43% did not use any sanitizers or antimicrobials during their poultry processing operations, only 24% used chemical sanitizers to clean their processing areas, and 33% were found to be processing outside (Scheinberg et al., 2013). In a similar study, McIntyre et al. (2014) surveyed 107 farmers’ market vendors in British Columbia, Canada on food safety-related behaviors and knowledge and revealed that 34% of farmers’ market vendors were unable to identify potentially hazardous foods (PHF) among a list of common foods and 29% were unable to identify proper methods of reducing the temperature of PHF (Mcintyre et al., 2014).

Although these studies have revealed high risk vendor retail behaviors and lack of knowledge in food safety procedures, these food safety gaps can be effectively addressed through educational programming and training. For decades, the retail food industry has incorporated employee food safety education and training into their operations as key components to ensure a successful and safe retail food business. Research has shown that effective food safety training increases food safety-related knowledge and attitudes, while improving skills and behaviors of employees (Medeiros et al., 2011; Soon et al., 2012). Based on these conclusions, it is generally accepted that effectively trained employees and managers can reduce the occurrence of foodborne illness at the retail level (Medeiros et al., 2011; Soon et al., 2012). However, due to the unique conditions in which farmers’ market vendors produce, store, transport, and sell their products at retail-like venues, commonly used retail food safety training programs such as ServSafe© or SafeMark© may not be suitable to address the unique issues related to farmers’ market food safety.
Therefore, based on the limited farmer’s market training climate in the U. S. and the results collected previously through a comprehensive needs assessment performed on farmers’ market vendors in Pennsylvania (Chapter 2), the purpose of this study was to develop and pilot-test a customized, retail food safety training program for farmers’ market vendors.

**Methods**

*Development of the farmers’ market vendor food safety training program*

The development of the farmers’ market vendor food safety training program utilized the Program Development Logic Model, commonly used in Cooperative Extension for the development and evaluation of new training programs (Figure 2). The situational analysis portion of the logic model was satisfied through a comprehensive needs assessment performed separately (Chapter 2). This needs assessment utilized retail food safety vendor observational analysis, vendor and health inspector surveys, and farmers’ market manager structured group interviews to determine gaps, needs, the knowledge and attitudinal base of farmers’ market vendors, and training preferences. Based on responses from vendor surveys and market manager group interviews, it was determined that a 3-hour, in-person, semi-interactive, classroom setting, training program would be developed.

The classroom setting training program utilizes PowerPoint presentation slides associated with a training and reference manual. The PowerPoint presentation slides and associated training activities are designed to be performed by Cooperative Extension educators experienced in retail food safety education. The topics covered for the training program were selected to address the needs and gaps identified in the comprehensive needs assessment, while also covering major areas of the FDA Food Code and applicable Pennsylvania state food safety regulations. The major training topics chosen were organized into seven sections or chapters of the Farmers’
Market Vendor Food Safety Resource Guide (Appendix H). Topics were discussed in more
detail within the resource guide, while the associated slides (Appendix I) were brief and used to
facilitate classroom learning. Content for each topic was developed, reviewed, and critiqued by
members of the Penn State Farmers’ Market Food Safety Team, which consisted of Cooperative
Extension food safety specialists, academic food safety experts, and food science doctoral
students. Content was mainly derived from the FDA Food Code, USDA Good Agricultural
Practices, and applicable Pennsylvania state regulations. The content was written specifically for
farmers’ market vendors to improve their knowledge, change their attitudes, and promote
behavior changes associated with proper retail food safety practices at the farmers’ market.

Although an effort was made to develop the content at a high-school grade level, due to the
necessary use of food safety related regulatory jargon, the readability grade level among chapters
of the training resource guide and associated slides ranged from grades 12-16 based on the Flesh-
Kincaid readability test.

Development of the pilot program and pre- and post-test assessment

To determine whether the developed training program would improve knowledge and
change attitudes of farmers’ market vendors on topics associated with food safety at farmers’
markets, a pilot test study was performed. The pilot test would also aid in the improvement of
the training program, and identify areas which could be modified or changed to better educate
the select audience. To specifically assess the change in knowledge and attitudes of farmers’
market vendors during the pilot program, a pre- and post-test assessment was developed. An
identical 30 question pre- and post-test consisted of three sections including: knowledge (19
multiple choice questions), attitudes (5 five-point Likert scale style questions), and demographics
(6 questions), in which key concepts were assessed before and after the training program.
The paper-based pre- and post-test assessment was printed on 8.5” x 11” inch paper using a font size of 12, and questions were printed on both the front and back of the paper. The draft test assessment was reviewed and critiqued by professors in the Department of Food Science at Penn State, graduate students, and multiple lay persons outside of the food science field in order to assess the overall validity, which included: readability of questions, length of time of completion, whether questions were understandable, and identification of grammatical errors. The final, 30-question pre- and post-test assessment was estimated to take participants 15-20 minutes to complete.

Since the pre- and post-test assessment portion of the pilot program involved the use of human subjects and their participation in a written test, approval from the Pennsylvania State Universities’ Institutional Review Board (IRB) was necessary to perform this research. The proposed methods and materials of the pre- and post-test assessment were submitted to the IRB through the Office of Research Protections at The Pennsylvania State University. It was determined on May 6, 2015, that the pre- and post-test assessment (STUDY00002587) was considered exempt from requiring IRB review and approval. However, to keep consistency with the previously performed comprehensive needs assessment, a consent form was used and participant identities were not associated with their responses. Participant identities remained confidential and only known to the approved researchers and principle investigator of this study. Collected data was kept secure in password-protected computer files and in locked cabinets and offices.

Recruitment and preparation of the pilot test programs

In an effort to reach farmers’ market vendors in multiple areas of Pennsylvania, it was decided to perform four consecutive pilot test programs, offered free of charge, in four different
cities in Pennsylvania. Pilot program sites were chosen based on their location to major farmers’ market hubs, their location within the state of Pennsylvania, the interest of farmers’ market vendors in those areas, and their availability. The first pilot program was located at the Department of Food Science, University Park, PA; the second was performed at the Lancaster Extension Educational Center, Lancaster, PA; the third was performed at a farmer training center called, The Seed Farm, located in Emmaus, PA; and the fourth was performed at the Penn State Center in Philadelphia, PA. Through collaborations with Penn State Cooperative Extension, a program description and associated online sign-up web page (C-vent; Tysons Corner, VA) was created and posted publicly on the Penn State Cooperative Extension, Food Safety Courses and Workshops site. Recruitment for the training program involved posting online public press releases, posting local newspaper advertisements, utilizing word of mouth, and by sending emails to Cooperative Extension educator farmers’ market contacts. Food safety Extension educators and market managers also were encouraged to attend the program to provide additional feedback. Recruitment materials also stated that vendors would receive a free lunch, extra food safety materials, such as thermometers and a free washable farmers’ market canvas shopping bag.

Conducting the pilot test training program and pre- and post-test assessments

Prior to the start of each pilot program session, participants were greeted and provided with a binder containing the Farmer’s Market Food Safety Resource Guide and associated Power Point slides. Once all of the participants had arrived, they were given a consent form (Appendix G), allowed time to read and ask questions, and once the consent form was signed, each participant was provided with the pre-assessment test. Each participant also was provided with a number to be used to link pre- and post-test results. Once all participants had completed the pre-
assessment test and they were collected, the training program began. The approximately 3-hour training program consisted of traditional presentation-style instruction, using the developed PowerPoint training slides (Appendix I). Two instructors, experienced and trained in retail food safety education, led the presentations. Presentations were split into chapters with short breaks taken after 2-3 chapter presentations, and a lunch break after approximately 2 hours of instruction. During each chapter presentation, instructors would reference applicable areas of the resource guide to promote its use as a reference tool, and participants were encouraged to ask questions throughout the instruction. Within certain chapters, instructors also utilized pre-planned interactive activities to increase participant learning and comprehension of the selected training topics. These activities included a demonstration of how to make and use a temporary hand washing and warewashing station, a thermometer calibration exercise, and an activity where participants would point out improper vendor behaviors from images taken at actual farmers’ markets. Numerous pictures also were utilized in the presentations to further illustrate the concepts. At the conclusion of the training program, participants were provided with the post-test assessment and an Extension evaluation survey, and given free food safety and incentive materials upon leaving. Participants were encouraged to take the training notebook, and use the resource guide in the near future.

Analysis of the pre- and post-test assessments

Pre- and post-test responses were compiled and measures of central tendency and percent responses were calculated to determine changes in individual and overall participant performance between pre- and post-test assessments. A one-way ANOVA was performed to compare the overall average of correct scores from the knowledge section between pre- and post-test assessments. A paired t-test was used to determine significant differences in attitudinal
question responses between pre- and post-test assessments. All statistical testing was carried out using SPSS; IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

**Results**

The average correct response rates for knowledge questions from the pre- and post-test assessments were 63% (12/19) and 79% (15/19), respectively (Table 2). One-way ANOVA analysis demonstrated that the increase in correct response rate observed in post-test assessments was statistically significant (p<0.05). On average, individual participants increased their number of correct knowledge question scores by 21% (4/19), when compared to pre-test assessment scores. However, changes in the number of correct knowledge question scores among participants ranged from -1/19 to 11/19. Further analysis, focusing on the change in scores among individual knowledge questions, revealed a wide range of change (Table 1). Changes in correct responses by participants observed between pre- and post-test assessments, ranged from -3/38 to 27/38. In particular, participant responses for Question 8 changed positively from 23% (9/38) to 71% (27/38) between pre- and post-test assessments. Questions 1e, 2, 5, 6, 7, 9, 11, and 15 also showed a positive change of 10 correct responses between pre- and post-test assessments. In contrast, questions 4, 13, and 1 showed a negative change of 1 correct responses between assessments. Additionally, a one-way ANOVA comparison of participant knowledge question scores, organized by education level (Bachelor’s degree and above, versus Associate degrees and below), years of farming (>3 years vs <3 years of farming), completion of previous food safety courses (yes versus no), and age (>35 vs <35), revealed no statistical differences (p<0.05) in both pre- and post-test assessments.
The results of the attitudinal section of the pre- and post-test assessment revealed little change between assessments (Figure 1). Among the five five-point Likert scale (1-Strongly Disagree, 5-Strongly Agree) questions, participants demonstrated an overall average agreement (>4.5) for all five questions, with little change between pre- and post-test assessments. Only responses to question 4 were found to change significantly (p<0.05) between assessments. Responses to demographic questions revealed that 68% (26/38) and 32% (12/38) identified as female and male, respectively. Eighty-two (82%; 31/38) of participants identified as white (non-Hispanic), 16% (6/38) identified as African American, and 1 participant identified as Native American (Table 6). Exactly half (19/38) of participants had achieved a Bachelor’s degree or higher or Associate’s degree or lower (Table 3), and 37% (14/38) had stated they had previously attended a food safety training course (Table 5). Additionally, over half (58%; 22/38) of the vendors had been farming less than 2 years, with 18% (7/38) stating they have farmed for over 5 years (Table 4).

Discussion

Sources have estimated that U. S. organizations spent $164.2 billion on employee learning and development in 2012 (Anonymous, 2013). In the U. S. retail food industry, food safety training for managers and employees has been universally adopted in an effort to comply with U. S. food safety regulations and ensure the safety of consumers. The growth of farmers’ markets in the U. S. and the risks associated with farmers’ markets highlighted through recent research, has resulted in many local and state municipalities to view farmers’ markets as a retail environment, and in turn, requiring farmers’ market vendors to comply with certain food safety regulations. In fact, between 2010 and 2011, Arizona, Florida, New Jersey, South Dakota, Washington, Pennsylvania, Maryland, and Oklahoma all passed specific state legislation
addressing farmers’ markets in the areas of food safety, food fraud, licensing, and establishing rules for the kinds of foods allowed to be produced for sale at farmers’ markets (O’brien, 2011). It is likely that if the trend in farmers’ market growth and expansion continues across the U. S., increased regulatory oversight is likely, and the need for food safety training designed specifically for farmers’ market vendors will increases.

In this study, a practical and customized 3-hour, in-person, farmers’ market food safety training program was developed and pilot tested in Pennsylvania. The results of the pilot study demonstrated that a combination of a comprehensive training resource guide with traditional slide presentation training methods, resulted in a significant gain in knowledge and change in attitudes among farmers’ market vendor participants. However, since behavior changes were not measured in the pre- and post-test assessment, it is unknown whether the increased knowledge and change in attitudes would result in actual behavior changes. It is also important to note that improvements in correct knowledge scores between pre- and post-test assessments varied among participants, with 5 participants scoring poorer in the post-test assessment. Alternatively, 12 participants improved their scores dramatically, improving their knowledge scores by over 30% between pre- and post-test assessments.

Interestingly, the results of the attitudinal section of the pre-test assessment revealed an already high agreement among participants on the importance of hygiene, hand washing, cross contamination, thermometer use, and food safety hazards at the farmers’ market. Attitudes on thermometer use were the only topic which participants showed a significant increase in agreement between pre- and post-test assessments. It is suspected that the use of the thermometer calibration exercise during the training program improved participant appreciation of its importance, potentially revealing the success of the use of interactive exercises to change
participant attitudes. The results of this study also revealed that age, educational degree attainment, years of farming, or the completion of a previous food safety course did not result in significantly different scores among participants. These results suggest that demographic and even educational background differences among participants had little bearing on their knowledge question performance, and that the training was effective in reaching participants of varied backgrounds.

While the results of this pilot test study revealed positive gains in knowledge and attitudes about farmers’ market food safety, future evaluation of this training program is needed to measure its effectiveness on behavior changes at the farmers’ market. Short (3-6 months) and long term (1-2 years) evaluations, which involve administering the post-test assessment, could reveal whether knowledge is retained or lost, while direct observations of participant behaviors at the farmers’ market could measure actual behavior changes. The results of this study and the development of a new farmers’ market food safety training program may be of interest to food safety educators and local and/or state public health agencies in the U. S.
References


Table 1: Individual knowledge question results and change in scores among pre- and post-test assessments.

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<th>Q1b</th>
<th>Q1c</th>
<th>Q1d</th>
<th>Q1e</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
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<th>Q12</th>
<th>Q13</th>
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</thead>
<tbody>
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<td>14</td>
<td>9</td>
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<td>24</td>
<td>22</td>
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<td></td>
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</tr>
<tr>
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<td>37</td>
<td>32</td>
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Table 2: Individual and average farmers’ market vendor knowledge question results and change in performance among pre- and post-test assessments.

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<tr>
<th>Vendor (n=38)</th>
<th>Pre-test number of correct questions (n=19)</th>
<th>Percent score</th>
<th>Post-test number of correct questions (n=19)</th>
<th>Percent score</th>
<th>Change in number of correct questions</th>
<th>Percent change in score</th>
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<td>42</td>
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</tbody>
</table>

Total Average Score

<table>
<thead>
<tr>
<th>Total Average Score</th>
<th>Pre-test number of correct questions (n=19)</th>
<th>Percent score</th>
<th>Post-test number of correct questions (n=19)</th>
<th>Percent score</th>
<th>Change in number of correct questions</th>
<th>Percent change in score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12/19 (63%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15/19 (79%)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4/19 (21%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Different lower case letters represent significant difference between total average pre- and post-test scores by one-way ANOVA analysis (p<0.05).
Table 3: Demographics of educational degree attainment among participating farmers’ market vendors.

<table>
<thead>
<tr>
<th>No formal education</th>
<th>Elementary school (1st to 6th grade)</th>
<th>Middle School (6th to 8th grade)</th>
<th>Attended high school, but did not graduate</th>
<th>High school graduate (or completed GED)</th>
<th>Some college credit, but less than 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>3% (1/38)</td>
<td>0%</td>
<td>3% (1/38)</td>
<td>3% (1/38)</td>
<td>3% (1/38)</td>
</tr>
<tr>
<td>1 or more years of college, no degree</td>
<td>Associate degree</td>
<td>Bachelor's degree</td>
<td>Master's degree</td>
<td>Doctoral degree</td>
<td>I do not wish to answer</td>
</tr>
<tr>
<td>24% (9/38)</td>
<td>16% (6/38)</td>
<td>37% (14/38)</td>
<td>11% (4/38)</td>
<td>3% (1/38)</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 4: Years of farming among participating farmers’ market vendors.

<table>
<thead>
<tr>
<th>Less than 1 year</th>
<th>1-2 years</th>
<th>2-3 years</th>
<th>3-4 years</th>
<th>4-5 years</th>
<th>More than 5 years</th>
<th>I do not wish to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>42% (16/38)</td>
<td>16% (6/38)</td>
<td>11% (4/38)</td>
<td>8% (3/38)</td>
<td>0%</td>
<td>18% (7/38)</td>
<td>5% (2/38)</td>
</tr>
</tbody>
</table>

Table 5: Completion of previous food safety courses among participating farmers’ market vendors.

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>37% (14/38)</td>
<td>63% (24/38)</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 6: Demographics of age, gender, and race among participating farmers’ market vendors.

<table>
<thead>
<tr>
<th>18-21</th>
<th>22-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65 and over</th>
<th>I do not wish to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>13% (5/38)</td>
<td>37% (14/38)</td>
<td>16% (6/38)</td>
<td>8% (3/38)</td>
<td>24% (9/38)</td>
<td>0%</td>
<td>3% (1/38)</td>
</tr>
<tr>
<td>White (Non-hispanic)</td>
<td>Hispanic</td>
<td>African American</td>
<td>Native American</td>
<td>I do not wish to answer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82% (31/38)</td>
<td>0%</td>
<td>16% (6/38)</td>
<td>3% (1/38)</td>
<td>3% (1/38)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>32% (12/38)</td>
<td>68% (26/38)</td>
</tr>
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</table>
Figure 1: Average attitudinal question scores among pre- and post-test assessments.

Note: Different lower case letters represent significant difference in average attitudinal scores within each question (p<0.05).
<table>
<thead>
<tr>
<th>Situational Analysis</th>
<th>Priority Setting</th>
<th>Program Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the current needs?</td>
<td>Filters: Mission Vision Values Mandates Resources Local dynamics Collaborators Competitors</td>
<td>Inputs: What we invest: Time Staff Money Materials Research Equipment</td>
</tr>
<tr>
<td>What is the knowledge base?</td>
<td>Outputs: What we do: Workshops Training Publications Media work Curriculum Assessments Facilitation Counseling Volunteer development Recruitment Productions</td>
<td>Who we reach: Participants Customers Citizens</td>
</tr>
<tr>
<td>Intended Outcomes</td>
<td>Outcomes: Short-term Learning: Awareness Knowledge Attitudes Skills Opinions Aspirations Motivation</td>
<td>Medium- Term Action: Behavior Practice Decisions Policy Social Action</td>
</tr>
<tr>
<td></td>
<td>Impacts: Long-term Conditions: Economic Social Environmental Civic</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Program development Logic Model (Gibson, 2001).
Chapter 5
Conclusions and future research
Conclusions

The purpose of this multi-year, interdisciplinary study was to determine and assess food safety gaps of vendors of farmers’ markets in Pennsylvania through a comprehensive needs assessment, as well as microbiological sampling and analyses of farmers’ market produce and meat products. The results of these findings were used to develop and pilot test a new food safety training program specifically designed for farmers’ market vendors in Pennsylvania.

A comprehensive needs assessment was accomplished using four tools: 1) the use of direct concealed observations of farmers’ market vendors in the retail setting; 2) farmers’ market vendor exploratory, knowledge and attitudinal surveys; 3) Pennsylvania Department of Agriculture (PDA) inspector observational surveys; and 4) market manager structured group interviews. Combined, these methods provided critical insight into the actual behaviors of farmers’ market vendors and allowed for a comparison between self-reported behaviors and actual, observed behaviors that occur in retail farmers’ market settings. The combined observational and survey assessment results also revealed important gaps in retail food safety behaviors, knowledge, and attitudes among Pennsylvania farmers’ market vendors, while market manager interviews provided key insights into the causes of these gaps and potential strategies that could be implemented through training and education.

In addition to assessing food safety gaps of farmers’ market vendors in Pennsylvania, risk factors in foods also were identified using microbiological sampling and analyses of farmers’ market produce and meat. Microbiological methods focused on measuring the concentration and presence of hygiene indicators, including coliforms, fecal coliforms, *E. coli*, and *Listeria* spp. The presence of these organisms in select produce and meat products would provide insight into the sanitary conditions in which they are exposed to; either on the farm, in the production area,
or in the retail environment. Phylogenetic molecular characterization and identification of the presence of ExPEC and STEC associated virulence genes performed on isolated *E. coli* cultures also was used to provide additional insight into ecological characteristics and potential public health risks associated with the presence of those isolates in farmers’ market meat and produce. The overall results of this assessment demonstrated that a notable percentage of select produce and meat obtained from farmers’ markets in Pennsylvania harbored varied concentrations of fecal coliforms, *E. coli*, and *Listeria* spp. These results indicate that sampled farmers’ market produce and meat came into contact with poor sanitary conditions either prior to sale or in the retail environment. The results also revealed previously unreported unique phylogenetic distributions of *E. coli* isolated from retail produce and meat obtained from farmers’ markets, providing additional insight into the phylogenetic distribution of *E. coli* in agricultural products sold at retail. Furthermore, this study identified that *E. coli* present on retail produce and meat sold at farmers’ markets, can possess ExPEC associated virulence genes, potentially revealing a new important reservoir for ExPEC virulence gene acquisition.

A comparison of the results of the comprehensive needs assessment and microbiological sampling and analysis revealed several important conclusions. Improper behaviors and lack of knowledge related to hand washing and glove use was found to be an important risk factor. Although behaviors at the farm were not observed in this study, it is suspected that these same behaviors may be performed during the harvest and processing of produce and prior to sale at farmers’ markets. The microbiological results suggest that a lack of adequate hand washing and/or glove use at the farm or at the farmers’ market could result in the cross contamination of these foods with *E. coli* originating from the farm or vendor. Furthermore, the use of wood
surfaces at farmers’ markets could be an additional source of contamination, especially when products are placed on uncovered wooden surfaces or not sanitized adequately.

The overall lack of knowledge and use of thermometers by farmers’ market vendors was an important risk factor identified in this study. Although meat sampled in this study was presumably processed and packaged in a USDA-FSIS inspected facility, the lack of thermometer use might suggest that meat sampled in this study could have been temperature abused in storage or at the farmers’ market, allowing for the recovery and growth of injured E. coli on meat products. The presence of E. coli and Listeria spp. on meats sampled in this study also could be indicative of the lack of use of pre-packaging and poor alternative packaging methods used by farmers’ market vendors in this study. Since meat vendors may have the ability to re-package their products under federal retail exemptions or package their meat products, such as ground beef, at the farmers’ market, additional opportunities exist for the contamination of raw meat sold at farmers’ markets.

Based on these results and conclusions, it was determined that food safety training for farmers’ market vendors in Pennsylvania could address food safety knowledge and behavioral gaps, potentially leading to safer foods sold at farmers’ markets. Preferences collected from vendor surveys and market manager interviews guided the development of the new farmers’ market food safety training program. Training materials were evaluated by several food safety specialists and educators, with the majority of the content derived from the FDA Food Code and applicable Pennsylvania food safety regulations. In its final, piloted form, the newly-developed training program consisted of a comprehensive farmers’ market food safety resource guide, used as a training tool and reference, in addition to a 3-hour PowerPoint presentation, organized into seven sections with lectures, demonstrations, and interactive activities.
To assess the training program’s ability to improve knowledge and change attitudes of farmers’ market vendors, the program was piloted in four locations throughout Pennsylvania. Based on a pre- and post-test knowledge and attitude assessment, completed by farmers’ market vendor participants of the pilot training programs, the results revealed that the training program produced a significant increase in knowledge and positive change in attitudes among participants. These results demonstrate that a customized, in-person training program, specifically designed to address gaps identified through a comprehensive needs assessment, is an effective strategy for improving the food safety knowledge and changing the attitudes of farmers’ market vendors in Pennsylvania.

**Future research**

Future evaluations of the developed training program are necessary to determine whether measured knowledge gains resulted in actual behavior changes at the farmers’ market. These evaluations should include short-term and long-term assessments utilizing observational assessments, as well as knowledge and attitudinal surveys. Short-term evaluations focused on measuring knowledge retention could involve the re-testing of vendor participants using the developed pre- and post-test assessment piloted in the initial training program, and observe those same participants perform tasks taught to them in the training program, including: thermometer calibration, proper hand washing using a temporary hand washing station, cleaning and sanitizing food contact surfaces, cleaning and sanitizing utensils in a temporary ware washing sink, and proper cold storage of TCS foods. Vendor participants of future training programs could also be observed using direct-concealed observational methods directly after the training program to determine if knowledge gains translate into behavioral changes at the market. This method could also be employed repeatedly following the training program to evaluate both short-
term and long-term effects of trained participants. Future uses of this training program could also be formatted as an online program. However, online training methods must be piloted and tested, while ensuring that non-computerized forms of the program remain viable for the large population of vendors who do not use computers on a regular basis.

One major limitation to the needs assessment portion of this study, was the inability of researchers to observe farmers’ market vendors preparing foods for sale on their actual farm or in their processing areas. Future studies are needed to observe farmers’ market vendors from “farm-to-fork” in order to identify the actual conditions, procedures, and types of equipment used to prepare various foods for sale at farmers’ markets. These studies would require the use of multiple evaluative tools, including surveys, observational assessments, as well as microbiological swabbing and sampling. These studies could also attempt to enroll select vendors in the developed training program, and evaluate the effects of the training program on vendor behaviors at both the retail site and at the farm or processing facility following training. Through this kind of research, future educational training interventions can be further customized to address challenges faced by farmers and processors outside of the retail environment.

An additional area not covered by this study is the role of consumers in the farmers’ market food safety continuum. There are few studies that have investigated strategies for educating consumers on food safety risks unique to farmers’ markets, and/or which have explored ways to use consumers to influence vendors to invest more of their time in proper food safety practices. Future studies could evaluate the best ways to provide food safety education to consumers who shop at farmers’ markets, while also determining consumer gaps in food safety knowledge and behaviors specific to farmers’ markets. Future studies could also evaluate the
specific influence that consumers can have on farmers’ market vendors through their questioning of vendor’s practices or through specific statements which consumers convey to vendors about their concerns regarding food safety. It is unknown whether a question, such as “have you washed your hands today” stated from a consumer to a vendor might influence vendor hand washing practices. Future studies are needed to explore these areas which could reveal approaches or solutions to improve food safety at farmers’ markets.

Farmers’ markets provide a unique venue to obtain agricultural food products which have not been exposed to conventional antimicrobial interventions and/or practices. Due to these conditions, the isolation of bacteria of public health significance associated with products, such as produce and meat sold at farmers’ markets, can be more easily and successfully performed, allowing for a more in-depth understanding of these organisms and the environmental reservoirs in which they may reside. Produce and meat obtained from farmers’ markets also may be ideal for identifying existing or emerging spoilage microorganisms and their effects on select agricultural food products, like produce. Due to the limited microbiological surveillance of raw produce products sold at both conventional retail supermarkets and non-conventional direct-to-consumer venues, like farmers’ markets, future survey studies are needed to further assess the microbiological conditions of produce sold at U.S. retail venues, and the data are needed to develop better risk assessments, which can evaluate the usefulness of hygiene indicator and pathogen testing in agricultural products such as produce.

Further exploration into the phylogenetic ecology of E. coli on produce and meat obtained from both farmers’ markets and conventional retail or farm sources also may further improve the understanding of the survival and presence of E. coli in farming environments. The results of this study provided further evidence that the phylogenetic clustering of E. coli is not
random, and the distribution of specific phylogroups could be associated or influenced by certain environmental niches or hosts. Future studies focused on generic *E. coli* testing of agricultural environments, livestock, wild animals, and humans working in farming environments which include phylogenetic and MLST characterization are needed to determine if a true relationship exists between phylogeny and specific *E. coli* reservoirs or hosts.

The results of this study also revealed that *E. coli* containing ExPEC-associated virulence genes can be found on raw agricultural products like produce, sold at farmers’ markets. These results provide evidence that ExPEC-associated virulence genes are present in agricultural environments, potentially providing a natural source of gene transfer among *E. coli* existing in these environments. However, more research is needed to determine the significance of these findings to evaluate the risk and effects of ingesting foods which harbor *E. coli* containing two or more of the currently known ExPEC-associated virulence genes. Future studies should also include the sampling of poultry to account for Avian pathogenic *E. coli* (APEC), in addition to meat and produce, and those products should also be screened for all known ExPEC-associated virulence genes to determine the true prevalence of ExPEC in agricultural food products sold at retail.

Lastly, due to the geographical limitations of this study, future exploration into the behaviors, knowledge, and attitudes of farmers’ market vendors, as well as the microbiological analysis of farmers’ market sold food products, must be performed in other states across the U. S. to account for factors which may be unique to certain regions of the country. Differences in climate, regulatory atmosphere, socioeconomic features, and other factors may result in food safety risk factors unique to farmers and farmers’ market vendors located throughout the U. S. The research methods utilized in this study may be used locally or nationwide, providing food
safety educators and public health specialists with the necessary data to develop education and training strategies to address food safety risks and further support and sustain farmers’ markets in the U. S.
Appendix A

Direct concealed observation’s market characteristics and vendor characteristics question routes
Appendix A. Direct concealed observation’s market characteristics and vendor characteristics questions routes.

<table>
<thead>
<tr>
<th>Q1</th>
<th>Indoor or outdoor?</th>
<th>MC: Indoor/Outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2</td>
<td>Describe the market setting.</td>
<td>Open ended</td>
</tr>
<tr>
<td>Q3</td>
<td>Number of vendors?</td>
<td>Scale (0-500)</td>
</tr>
<tr>
<td>Q4</td>
<td>Number of patrons (approx.)?</td>
<td>Scale (0-500)</td>
</tr>
<tr>
<td>Q5</td>
<td>How many hand washing stations are available for patrons? (not a bathroom)</td>
<td>Scale (0-10)</td>
</tr>
<tr>
<td>Q6</td>
<td>How many communal hand washing stations available for vendors?</td>
<td>Scale (0-10)</td>
</tr>
<tr>
<td>Q7</td>
<td>Is food safety material provided for patrons?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td>Q8</td>
<td>How many vendors are selling meat (beef, lamb, pork)</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q9</td>
<td>How many vendors are selling poultry?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q10</td>
<td>How many vendors are selling cheese?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q11</td>
<td>How many vendors are selling eggs?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q12</td>
<td>How many vendors are selling vegetables?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q13</td>
<td>How many vendors are selling fruit?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q14</td>
<td>How many vendors are selling baked goods?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q15</td>
<td>How many vendors are selling canned goods?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q16</td>
<td>How many vendors are selling prepared RTE foods?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q17</td>
<td>How many vendors are selling jams/jellies/sauces?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q18</td>
<td>How many vendors are selling milk?</td>
<td>Scale (1-50)</td>
</tr>
<tr>
<td>Q19</td>
<td>What other products are being sold?</td>
<td>Open ended</td>
</tr>
</tbody>
</table>

Notes: Open ended

Note: MC: Multiple choice
<table>
<thead>
<tr>
<th>Vendor Characteristics</th>
<th>Response Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1</strong> Condition of the surface used to hold and display food items?</td>
<td>MC: Clean/Slightly Soiled/Dirty/I can’t tell**</td>
</tr>
<tr>
<td><strong>Q2</strong> What is the table used to sell food items made of?</td>
<td>MC: Wood/Plastic/Metal/Other</td>
</tr>
<tr>
<td><strong>Q3</strong> Condition of the vendor clothing?</td>
<td>MC: Clean/Slightly Soiled/Dirty/I can’t tell**</td>
</tr>
<tr>
<td><strong>Q4</strong> Is the vendor wearing a hair covering?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td><strong>Q5</strong> Was the vendor doing any of the following?</td>
<td>MC: Smoking/Drinking/Eating/Chewing gum</td>
</tr>
<tr>
<td><strong>Q6</strong> Disposable glove use?</td>
<td>MC: No gloves present/Gloves present and used/Gloves present not used/Cold weather glove</td>
</tr>
<tr>
<td><strong>Q7</strong> If gloves are being used are any of the following observed?</td>
<td>MC: No gloves used/gloves used between raw and RTE/Gloves used between money and unpackaged food/Gloves used between unclean surface and unpackaged food/no improper glove use</td>
</tr>
<tr>
<td><strong>Q8</strong> If gloves are not being used are any of the following observed?</td>
<td>MC: Touch body then unpackaged food/touching money then unpackaged food/Coughing or sneezing then unpackaged food/Touch raw then RTE food/No improper food handling</td>
</tr>
<tr>
<td><strong>Q9</strong> Is hand sanitizer available for vendor use?</td>
<td>Yes/NO/NA</td>
</tr>
<tr>
<td><strong>Q10</strong> Vendor hand washing habits?</td>
<td>MC: No HW observed/No HW when required/HW after handling food or when required</td>
</tr>
<tr>
<td><strong>Q11</strong> Does the vendor display any certificates or other records of food safety training?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td><strong>Q12</strong> Are unpackaged raw foods placed directly on retail surfaces?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td><strong>Q13</strong> If yes, describe foods and surfaces</td>
<td>Open ended</td>
</tr>
<tr>
<td><strong>Q14</strong> How are food items packaged?</td>
<td>MC: Plastic bag at sale/Use paper bag at sale/Some foods pre-packed some not/All foods pre packed</td>
</tr>
<tr>
<td><strong>Q15</strong> Are foods which require cold storage stored in a cold storage container?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td><strong>Q16</strong> Is a thermometer available and/or used in the cold storage unit?</td>
<td>Yes/No/NA</td>
</tr>
<tr>
<td>Q17</td>
<td>What type of cold storage unit is used?</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Q18</td>
<td>Are samples of foods available?</td>
</tr>
<tr>
<td>Q19</td>
<td>What foods are offered as samples?</td>
</tr>
<tr>
<td>Q20</td>
<td>How are samples handled by the customer?</td>
</tr>
<tr>
<td>Q21</td>
<td>Does packaging contain a label with vendor contact information?</td>
</tr>
<tr>
<td>Q22</td>
<td>Does meat contain USDA seal and establishment number?</td>
</tr>
<tr>
<td>Q23</td>
<td>Does poultry contain proper exemption labeling?</td>
</tr>
<tr>
<td>Q24</td>
<td>Do raw milk products contain the required warning statement?</td>
</tr>
<tr>
<td>Q25</td>
<td>If products are made from raw milk, is it obvious to the customer they are raw milk based?</td>
</tr>
<tr>
<td>Q26</td>
<td>Does the vendor provide food safety information or recommendations?</td>
</tr>
<tr>
<td>Notes</td>
<td>Open ended</td>
</tr>
</tbody>
</table>
Appendix B

Farmers’ market retail food safety needs assessment survey, consent form, and verbal script
Appendix B. Farmers’ market retail food safety needs assessment survey, consent form, and verbal script

Verbal Script

Good Morning/Afternoon,

My Name is (state your name)

I am from the Department of Food Science at Penn State and we are conducting a survey in order to learn more about food safety issues effecting farmers’ markets and farmers’ market vendors.

This survey is being conducted for research purposes only, and the information you provide will help us understand more about farmers’ markets, and how we can develop future educational tools and programs to assist farmers’ market vendors like you, in providing safe and quality food products.

This questionnaire should take only 15 minutes to complete, and upon completion, you will receive $10 in cash for your participation. All information you provide will be kept confidential. The responses you provide on the survey will never be associated with your name or business name, and we will not share this information with anyone not involved in this study.

Would you like to participate in the survey?

If No:

Thank the vendor for their time, and leave the premise.

If yes:

Proceed with providing the vendor with the consent form and needs assessment survey.
Title of Project: Food Safety Practices of Farmers’ Market Vendors

Principal Investigator: Dr. Catherine Cutter, 433 Food Science Building, University Park, Pa 16802 (814)-865-8862 cnc3@psu.edu

Other Investigator(s): Joshua Scheinberg, 431 Food Science Building, University Park, Pa 16802, jas6387@psu.edu
Robson Machado, 434 Food Science Building, University Park, Pa 16802, als5929@psu.edu

1. Purpose of the Study: The purpose of this research is to explore the food safety knowledge, behaviors, and attitudes of farmers’ market vendors who sell food products in Pennsylvania.

2. Procedures to be followed: You will be asked to fill out the paper questionnaire (consisting of 38 questions). There is no time limit, you may skip questions, and can stop at any time.

3. Discomforts and Risks: There are no risks involved in this research, beyond those experienced in everyday life.

4. Benefits: The benefits to you include future invitations to training and future access to informational materials in the areas of food safety and food production customized for vendors who produce foods sold at farmers’ markets. The benefits to society include an overall safer food supply.

5. Duration/Time: The questionnaire will take approximately 20 minutes to complete.

6. Statement of Confidentiality: Your participation in this research is confidential. The data from this survey will be aggregated, stored and secured at Penn State University in a locked file cabinet or on password-protected computer files. Only Dr. Catherine Cutter and Joshua Scheinberg will have access to the data. Digital data (tabulated data from surveys) will be kept for three years after the conclusion of the research. We expect to conclude the research by 2015. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The Pennsylvania State University's Office for Research Protections and Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project. Your confidentiality will be kept to the degree permitted by the technology used.

7. Right to Ask Questions: Please contact Dr. Catherine Cutter at (814) 865-8862 or via email at cnc3@psu.edu with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University's Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.
8. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

9. **Payment for Participation:** You will be compensated $10 for your participation, however your name, address, and phone number are required to receive this compensation. This information is only required for Penn State accounting purposes to show proof of receipt of the cash incentive. This information will be kept secure, will not be associated with your survey responses, and NEVER released to any other party.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study given the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this consent form for your records.

_____________________________________________  ______________________
Participant Signature                              Date

_____________________________________________  ______________________
Name of Person Obtaining Consent                  Date
Section I: At the Market:

Instructions: Please check off one or multiple responses for the following questions.

1. What items do you sell at farmers’ markets? (Check all that apply).

□ Fruits          □ Beef          □ Raw Milk          □ Canned Vegetables
□ Vegetables     □ Goat          □ Pasteurized Milk    □ Canned Fruits
□ Other Meat     □ Raw Milk Cheese □ Pasteurized Cheese □ Canned Meat/Poultry
□ Raw Sausages   □ Pasteurized Cheese □ Jams/Jellies/Spreads □ Breads
□ Cooked Sausage □ Yogurt        □ Other Dairy Products □ Other Baked Goods
□ Chicken        □ Other Sausages □ Unpasteurized Cider  □ Other Juices (Pasteurized)
□ Turkey         □ Other Fowl     □ Other Juices (Pasteurized) □ Sauces/Salsas
□ Other Fowl     □ Chicken Eggs  □ Other Juices (Pasteurized) □ Other Juices (Pasteurized)
□ Fresh Seafood  □ Frozen Seafood □ Other Crafts and Goods □ Other Crafts and Goods
□ Frozen Seafood

Other (please list)________________________________________________________________________

2. Which percentage of the items that you sell at farmers’ markets, are raised, grown, processed, and/or made by another farmer or processor? (Please estimate).

□ Less than 10%
□ 10-20%
□ 20-30%
□ 30-40%
□ 40-50%
□ 50-60%
□ 60-70%
□ 70-80%
□ 80-90%
□ More than 90%
□ All of the items I sell are produced from other farmers or processors
□ All of the items I sell are produced by me or my employer
□ I do not know
3. If you sell raw produce, meats, or other raw foods, which foods are pre-packaged before selling them at farmers’ markets? (Check all that apply).

- □ Raw produce (fruits/vegetables) are pre-packaged
- □ Meat and/or poultry is pre-packaged
- □ Other raw foods I sell are pre-packaged
  Please List Other Foods____________________________________________
- □ All of my raw foods are packaged for the customer at the farmers’ market and are NOT pre-packaged
- □ I do not sell raw produce, meat, poultry, or other raw foods
- □ I do not know

4. If you sell food items that require cold storage, how do you store them at farmers’ markets?

- □ In a cooler with ice or ice packs
- □ In a cooler with NO ice or ice packs (food is already frozen)
- □ In a glass refrigerated deli case
- □ In a non-refrigerated deli case, but foods are packed on ice
- □ In an electrically-powered freezer or refrigerator
- □ In a pre-chilled or frozen ice box (non-electric/non-battery powered)
- □ I do not know

5. If you sell food items that require cold storage, do you use a thermometer at farmers’ markets to check the temperature of the foods?

- □ Yes
- □ No
- □ No, but all of my foods are stored on ice, so I know they are cold enough
- □ I do not know

6. If you use a thermometer at farmers’ markets, how often do you calibrate it?

- □ I don’t use a thermometer at the farmers’ market
- □ Before each market day
- □ Once every few days
- □ Once every few months
- □ I’ve never calibrated it
- □ I don’t know how to calibrate the thermometer I use
- □ I do not know
- □ Other
7. Do you clean or sanitize your food stand and/or deli cases with any of the following before each market day? (Check all that apply)

☐ Soap and water
☐ Chlorine/Bleach
☐ Sanitizing Wipes
☐ Other store bought cleaner (If other, please list) _____________________________________________

☐ I cover my food stand with a clean table cloth or disposable covering
☐ I do not clean my food stand because it is wood
☐ I do not clean my food stand
☐ I do not know

8. Have you ever been inspected by the PDA or local health department at a farmers’ market or on your farm? (Check all that apply)

☐ Yes
☐ No
☐ I do not know

9. If you offer food samples at farmers’ markets, how are they handled? (Check all that apply)

☐ I do not give out food samples
☐ I serve the customers individually
☐ I allow customers to pick up items with their hands
☐ I provide tooth picks or other utensil to customers for picking up food samples
☐ I do not know

10. Do you use disposable gloves to handle foods you sell at farmers’ market?

☐ Yes
☐ No
☐ I do not know

11. If you DO NOT use disposable gloves at farmers’ markets, do you use another technique to avoid touching foods with your bare hands? (Check all that apply)

☐ No
☐ All of my food is pre-packaged
☐ I reach inside a clean plastic bag, grab the food items, then turn the bag inside out
☐ I use tissue paper or other paper/plastic to pick up raw foods
☐ I use tongs or another utensil to handle raw foods
☐ I wash my hands routinely so I don’t worry about touching foods with bare hands
☐ Other (Please List): _____________________________________________

☐ I do not know
12. Please select the following responses that best describes your hand washing station: (Check all that apply)

- □ I provide my own hand washing station at my farmers’ market stand
- □ I share a hand washing station with another vendor
- □ I use a hand washing station or sink provided by the market for vendors only
- □ I use a sink at the market which is located in a public restroom
- □ I am not required to have a hand washing station, so I don’t have one
- □ I do not know

13. Please select the following responses that best describes your hand washing habits at the farmers’ market: (Check all that apply)

- □ I wash my hands at the beginning of the day before handling any food items and periodically throughout the day
- □ I wash my hands often whenever I feel I’ve made them unclean
- □ I use hand sanitizer or sanitizing wipes when I don’t have time or access to wash my hands
- □ I don’t have time to wash my hands often, but I’m only handling pre-packaged foods
- □ I do not know

14. Please select the following responses that best describes when you might wash your hands or use hand sanitizer at the farmers’ market: (Check all that apply)

(Please circle whether you wash your hands or use hand sanitizer for the items you have checked off)

- □ (I wash my hands/use hand sanitizer) before touching any food items IF I have touched my face or body
- □ (I wash my hands/use hand sanitizer) before touching any food items IF I have touched an unclean surface
- □ (I wash my hands/use hand sanitizer) before touching any food items IF I have touched raw meat, eggs, or poultry.
- □ (I wash my hands/use hand sanitizer) before handling food items IF I have handled money
- □ I don’t wash my hands often because I use disposable gloves
- □ I don’t wash my hands often because I only sell pre-packaged foods
- □ I do not know.
Section II: Food Safety Knowledge:

Instructions: Please circle the letter choice/choices for the following questions.

15. Select which behaviors might cause a vendor to accidentally make their food items unclean or contaminated with harmful bacteria (Circle all that apply)

   a) Licking fingers to get a better grip on a plastic bag, then handling foods for a customer with bare hands
   b) Handling money then touching unpackaged foods (no hand washing in between)
   c) Smoking outside then touching unpackaged foods (no hand washing in between)
   d) Eating at the stand, then touching unpackaged foods (no hand washing in between)
   e) Options A, C, and D
   f) All of the above
   g) I do not know

16. After which activity should a farmers’ market vendor wash his/her hands or change gloves? (Circle all that apply)

   a) After touching his/her face
   b) After wiping his/her nose, coughing, or sneezing
   c) After touching money
   d) After touching raw meats, eggs, and poultry
   e) Choices A, B and D
   f) All of the Above
   g) I do not know

17. Which is an example of cross-contamination at the farmers’ market? (Circle all that apply)

   a) Handling un-packaged raw meat, then handling raw produce (no hand washing in between)
   b) Un-packaged raw meats stored in the same deli case or cooler as cooked deli meat
   c) Using the same tongs for handling both raw and cooked foods
   d) Eggs and milk stored in the same cooler
   e) Options A, B, and C
   f) All of the above
   g) I do not know

18. Thermometers only have to be calibrated every few months.

   a) True
   b) False
   c) I do not know
19. **After which activity should thermometers be washed, rinsed, and sanitized?** (Circle all that apply)
   a. When the thermometer has been used and set down on an un-sanitized surface
   b. When the thermometer has been used on raw foods and before using it for cooked foods
   c. Once every hour, regardless of how it is used
   d. Thermometers aren’t designed to be washed and sanitized
   e. Both A and B
   f. All of the above
   g. I don’t know

20. **Which is a bacteria that is found naturally in the human nose, and can contaminate foods from sneezing, coughing, or someone touching their nose and then touching foods?** (Circle all that apply)
   a) Salmonella typhi
   b) Staphylococcus aureus
   c) Campylobacter jejuni
   d) Chicken Pox
   e) Choices A and C
   f) All of the above
   g) I don’t know

21. **Which of the following can be a source of pathogenic (harmful) bacteria at the farmers market?** (Circle all that apply)
   a) Public restrooms
   b) Customers’ hands
   c) Live animals
   d) Pallets, containers, and bins from the farm
   e) Ice used to cool un-packaged raw meat
   f) All of the above
   g) I do not know

22. **What temperature should milk, unfrozen raw meat, and unpasteurized apple cider be stored at the farmers’ market?**
   a) Less than 51°F
   b) Less than 41°F
   c) Less than 31°F
   d) I do not know
Section III: Food Safety Attitudes:

Instructions: Please circle your choice under each question.

To what extent do you agree or disagree with each of the following statements.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

(Circle your choice under each question)

23. PDA licensing requirements and inspections are important to keep foods sold at farmers’ markets safe.

24. I have sufficient knowledge in food safety and I don’t need any more training.

25. I have difficulty putting the food safety knowledge I currently have into practice at the farmers’ market.

26. I am concerned about pathogenic (harmful) bacteria being in my food products.

27. I want to learn more about food safety, but I don’t know where or how to get good information.

28. I am prepared to handle a situation where a food item I sold to a customer makes them sick.

29. I would focus more on food safety if it helped me sell more products at the farmers’ market.

30. I would change my food safety practices if I discovered my food products were contaminated with harmful bacteria.
Section IV: Food Safety Training:

Instructions: Please check off one or multiple responses for the following questions.

31. Have you ever taken any food safety classes?
   - □ Yes
   - □ No
   - □ I do not know

If you answered YES, please answer question 32, if NO, skip to question 33.

32. What types of food safety courses have you taken?
   - □ College courses taken in person or over the internet
   - □ Cooperative Extension courses taken in person or over the internet
   - □ ServSafe or other food safety certification course
   - □ Food safety training from a current or previous employer
   - □ Other (If other, please list) _____________________________________

33. What is your preferred method of receiving training or learning something? (Check all that apply)
   - □ Computer-based training with power point slides
   - □ Computer-based training with videos
   - □ In person training (classroom setting) in a large group
   - □ In person training (classroom setting) in a small group
   - □ In person training outside of the classroom (at the market, farm, or worksite)
   - □ One-on-one in person training (at the market, farm, or worksite)
   - □ I do not know

34. When you are being taught something, which of the following techniques help you learn better? (Check all that apply)
   - □ Hands on exercises
   - □ Group exercises
   - □ Pictures, videos, or watching people doing the activity that you are being taught
   - □ Studying for a test
   - □ Playing a game to help remember the lessons
   - □ One on one time with the instructor to ask questions and review the lesson
   - □ Other (If other, please list) _________________________________
   - □ I do not know
35. I would attend a food safety training/workshop hosted by Penn State Cooperative Extension.
   □ Yes, but only if it is free
   □ Yes, and I would be willing to pay $25 to $50
   □ Yes, and I would be willing to pay $50 to $100
   □ No, but I would like information on food safety pertaining to my food products
   □ No, and I do not want any additional assistance or information from Penn State

36. Where would you be willing to travel to receive food safety training? (Check all that apply)
   □ Penn State University (State College, PA)
   □ Penn State University (closest satellite campus)
   □ Closest county Extension office
   □ The farmers’ market which I sell at
   □ A public hall or school in my home town
   □ I would not travel farther from my own home for training
   □ I would prefer not to travel, but would receive training from an internet site
   □ I do not know

37. What is the highest degree or level of school you have completed? If currently enrolled, mark the previous grade or highest degree received.
   □ No formal schooling completed
   □ Elementary school (1st to 6th grade)
   □ Middle School (6th to 8th grade)
   □ Attended high school, but did not graduate
   □ High school graduate (or completed GED)
   □ Some college credit, but less than 1 year
   □ 1 or more years of college, no degree
   □ Associate degree
   □ Bachelor’s degree
   □ Master’s degree
   □ Doctorate degree
   □ I do not wish to answer

38. What is your age?
   □ 18-21
   □ 22 to 34
   □ 35 to 44
   □ 45 to 54
   □ 55 to 64
   □ 65 and over
□ I do not wish to answer

Appendix C

Pennsylvania Department of Agriculture public health inspector needs assessment survey
and consent form
Appendix C. Pennsylvania Department of Agriculture public health inspector needs assessment survey and consent form.

Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: Food Safety Practices of Farmers’ Market Vendors

Principal Investigator: Dr. Catherine Cutter, 433 Food Science Building, University Park, PA 16802
(814) 865-8862, cnc3@psu.edu

Other Investigator(s): Joshua Scheinberg, 431 Food Science Building, University Park, PA 16802
jas6387@psu.edu
Robson Machado, 434 Food Science Building, University Park, PA 16802
ram471@psu.edu

1. Purpose of the Study: The purpose of this research is to explore the food safety knowledge, behaviors, and attitudes of farmers’ market vendors who sell food products in Pennsylvania.

2. Procedures to be followed: You will be asked to fill out the questionnaire (consisting of approximately 30 questions). The paper questionnaire will be provided to you by one of the research investigators.

3. Discomforts and Risks: There are no risks involved in this research, beyond those experienced in everyday life.

4. Benefits: There are no personal benefits. The benefits to society include an overall safer food supply.

5. Duration/Time: The questionnaire will take approximately 20 minutes to complete.

6. Statement of Confidentiality: Your participation in this research is confidential. The data from questionnaires will be aggregated, stored and secured at Penn State University in a locked file cabinet or password-protected computer files. Only Dr. Catherine Cutter and Joshua Scheinberg will have access to the data. Digital data (tabulated data from questionnaires) will be kept for three years after the conclusion of the research. We expect to conclude the research by 2015. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The Pennsylvania State University’s Office for Research Protections and Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project. Your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

7. Right to Ask Questions: Please contact Dr. Catherine Cutter at (814) 865-8862 or via email at cnc3@psu.edu with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.
8. **Voluntary Participation:** Your decision to participate in this study is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty. You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study given the information outlined above, please sign your name and indicate the date below. You will be given a copy of this consent form for your records.

_____________________________________________  ___________________
Participant Signature                      Date
Initial Qualifier Question:

Have you ever inspected a farmers’ market or farmers’ market vendor?

○ Yes
○ No

If you selected “No”, Please STOP and return the questionnaire.

If you selected “Yes,” Please continue with the remainder of the questionnaire.

Section1: General Farmers’ Market Inspection Questions:

Instructions:

For the following questions, please answer to the best of your ability. If you cannot answer the question exactly, please estimate and choose the closest response.

Please circle or fill in the bubble next to your selection.

1.) How many farmers’ market vendors have you inspected in the last three years?

○ 1-5
○ 6-15
○ 16-30
○ 31-50
○ 51-70
○ More than 70
○ I do not know

2.) Please select which types of food categories were being sold by the vendors you have inspected: (Check more than one answer, if appropriate)

○ Pre-packaged, non potentially hazardous foods
○ Unpackaged, non potentially hazardous foods
○ Pre-Packaged, potentially hazardous foods
○ Unpackaged, potentially hazardous foods
○ Ready-to-eat on the premises foods
○ Other
○ All of the above
○ I do not know
3.) Please select which types of food items were being sold by the vendors you have inspected (Check more than one answer, if appropriate)

- Produce (fruits and vegetables)
- Unpasteurized milk
- Pasteurized milk
- Other dairy products (yogurt, cheese, sour cream, etc.)
- Eggs
- Meat (beef, pork, goat, sheep)
- Poultry (chicken, turkey, other fowl)
- Fresh seafood
- Cooked or smoked seafood
- Raw sausages or other raw mixed meat/poultry processed products
- Ready-to-eat cooked or fermented sausages
- Baked bread products (loafs, rolls, bagels, pretzels, etc.)
- Other baked products (pies, cakes, cookies, etc.)
- Canned fruit products (jams, jellies, spreads, etc.)
- Other canned foods (vegetables, fruits, meats, etc.)
- Sauces, salsas, or dressings
- Unpasteurized juices
- Ready-to-eat cooked foods prepared at the market
- Other
- All of the above
- I do not know

Please continue to the next page…
Section 2: Results of Past Inspections of Farmers’ Market Vendors:

Instructions:

For the following questions, please select a response which indicates the estimated frequency that you have found a certain inspection item "Out of Compliance" during inspections of Farmers’ Market Vendors that YOU have performed in the past three years. Reference the “PDA Inspection Form” for farmers’ market vendors, if needed.

For each question, please select a response which reflects an estimated percentage of those inspection items which were “Out of Compliance.” Use your best judgment or guess to answer each question using the following scale:

Almost Never (less than 5%);
Rarely (5%-10%);
Sometimes (10%-40%);
Often (40%-70%);
Usually (70%-90%);
Almost Always (more than 90%).

Please also select a “most common reason for the non-compliance” for each question.

<table>
<thead>
<tr>
<th>4. Good Hygienic Practices</th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Proper eating, tasting, drinking, or tobacco use</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be Out of Compliance</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>○ Eating, tasting, or drinking is observed during food preparation or processing</td>
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<td></td>
</tr>
<tr>
<td>○ Eating, tasting, or drinking is observed while handling food products at retail</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>○ Vendors are unaware that eating, tasting, drinking, or tobacco is unhygienic at the retail environment</td>
<td></td>
<td></td>
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<tr>
<td>○ Other</td>
<td></td>
<td></td>
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<tr>
<td>○ I do not know</td>
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</tr>
</tbody>
</table>
### 5. Good Hygienic Practices

<table>
<thead>
<tr>
<th></th>
<th>Almost Never (&lt;5%)</th>
<th>Rarely (5%-20%)</th>
<th>Sometimes (20%-50%)</th>
<th>Often (50%-80%)</th>
<th>Usually (80%-95%)</th>
<th>Almost Always (&gt;95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. No discharge from eyes, nose and mouth</td>
<td>○ ○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**b. Most common reason(s) for non-compliance (mark all that apply):**
- ○ I have never observed this inspection item to be **Out of Compliance**
- ○ Discharge from eyes, nose, and mouth is observed during food preparation or processing
- ○ Other
- ○ I do not know

### 6. Preventing Contamination by Hands

<table>
<thead>
<tr>
<th></th>
<th>Almost Never (&lt;5%)</th>
<th>Rarely (5%-20%)</th>
<th>Sometimes (20%-50%)</th>
<th>Often (50%-80%)</th>
<th>Usually (80%-95%)</th>
<th>Almost Always (&gt;95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Hands clean &amp; properly washed</td>
<td>○ ○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**b. Most common reason(s) for non-compliance (mark all that apply):**
- ○ I have never observed this inspection item to be **Out of Compliance**
- ○ Vendors do not have access to a hand-washing station
- ○ Vendors use hand sanitizer in place of hand-washing
- ○ Vendors are unaware hand-washing is required or necessary
- ○ Other
- ○ I do not know

### 7. Preventing Contamination by Hands

<table>
<thead>
<tr>
<th></th>
<th>Almost Never (&lt;5%)</th>
<th>Rarely (5%-20%)</th>
<th>Sometimes (20%-50%)</th>
<th>Often (50%-80%)</th>
<th>Usually (80%-95%)</th>
<th>Almost Always (&gt;95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. No bare hand contact with RTE foods or approved alternative method properly followed.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**b. Most common reason(s) for non-compliance (mark all that apply):**
- ○ I have never observed this inspection item to be **Out of Compliance**
- ○ Bare hand contact is observed with RTE foods, with no use of proper hand-washing
- ○ Vendors are unaware that bare hand contact is not approved when handling RTE foods
- ○ Vendors have disposable gloves but do not use them or use them improperly
- ○ Other
- ○ I do not know
<table>
<thead>
<tr>
<th>8. Preventing Contamination by Hands</th>
<th>Almost Never</th>
<th>Rarely 5%–20%</th>
<th>Sometimes 20%–50%</th>
<th>Often 50%–80%</th>
<th>Usually 80%–95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate hand-washing facilities supplied &amp; accessible</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>o I have never observed this inspection item to be Out of Compliance</td>
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<tr>
<td>o Farmers markets do not provide a proper hand-washing station</td>
<td></td>
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</tr>
<tr>
<td>o Vendors are unaware of the requirement for a hand-washing station</td>
<td></td>
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<tr>
<td>o Public bathrooms are available and used as hand-washing stations</td>
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<tr>
<td>o Other</td>
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<tr>
<td>o I do not know</td>
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<tr>
<td>9. Approved Source</td>
<td>Almost Never</td>
<td>Rarely 5%–20%</td>
<td>Sometimes 20%–50%</td>
<td>Often 50%–80%</td>
<td>Usually 80%–95%</td>
<td>Almost Always &gt;95%</td>
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</tr>
<tr>
<td>Food in good condition, safe, &amp; unadulterated</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
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<tr>
<td>o I have never observed this inspection item to be Out of Compliance</td>
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<tr>
<td>o Food is in poor condition</td>
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<tr>
<td>o Food is unsafe or adulterated</td>
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<tr>
<td>o Other</td>
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<tr>
<td>o I do not know</td>
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<tr>
<td>10. Protection from Contamination</td>
<td>Almost Never</td>
<td>Rarely 5%–20%</td>
<td>Sometimes 20%–50%</td>
<td>Often 50%–80%</td>
<td>Usually 80%–95%</td>
<td>Almost Always &gt;95%</td>
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</tr>
<tr>
<td>Food separated and protected</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
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<td></td>
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<tr>
<td>o I have never observed this inspection item to be Out of Compliance</td>
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<tr>
<td>o Food is not properly protected from sources of contamination</td>
<td></td>
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<tr>
<td>o Raw foods are not properly separated from each other or other food items leading to cross contamination</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>o Vendors are unaware of proper methods to separate and protect foods from cross-contamination</td>
<td></td>
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<tr>
<td>o Vendors are unaware of the requirements to properly separate and protect foods from cross-contamination</td>
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<tr>
<td>o Other</td>
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<tr>
<td>o I do not know</td>
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</tr>
</tbody>
</table>
11. Protection from Contamination

<table>
<thead>
<tr>
<th>Category</th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%–20%</th>
<th>Sometimes 20%–50%</th>
<th>Often 50%–80%</th>
<th>Usually 80%–95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Food-contact surfaces: cleaned &amp; sanitized</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
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<td></td>
</tr>
<tr>
<td>○ Foods are placed into secondary containers that are not clean and/or sanitized</td>
<td></td>
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</tr>
<tr>
<td>○ Foods are placed directly onto primary retail displays that are not clean and/or sanitized</td>
<td></td>
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</tr>
<tr>
<td>○ Utensils, cooking tools, or other food contact surfaces are not properly cleaned and/or sanitized</td>
<td></td>
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<tr>
<td>○ Vendors are unaware of the requirements to clean and sanitize food contact surfaces</td>
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<td></td>
</tr>
<tr>
<td>○ Vendors are unaware of how to properly clean and sanitize food contact surfaces</td>
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<td></td>
</tr>
<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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</tbody>
</table>

12. Food Temperature Control

<table>
<thead>
<tr>
<th>Category</th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%–20%</th>
<th>Sometimes 20%–50%</th>
<th>Often 50%–80%</th>
<th>Usually 80%–95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Proper cooling methods used adequate equipment for temperature control</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
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<td></td>
</tr>
<tr>
<td>○ Containers used to cool or keep foods cold are not adequate or working properly</td>
<td></td>
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<tr>
<td>○ Temperature control is inadequate due to the lack of a temperature monitoring device available</td>
<td></td>
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</tr>
<tr>
<td>○ Vendors are unaware of the requirements for proper cooling methods and temperature control</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>○ Vendors are unaware of how to properly cool and control the temperature of stored foods</td>
<td></td>
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<tr>
<td>○ Other</td>
<td></td>
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<tr>
<td>○ I do not know</td>
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</tbody>
</table>
### 13. Food Temperature Control

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Thermometer provided and accurate</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>I have never observed this inspection item to be <strong>Out of Compliance</strong>.</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>o</td>
<td>No thermometer is available or used by vendors</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>o</td>
<td>Thermometers are used by vendors but are inaccurate</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>o</td>
<td>Thermometers are available but vendors are not using or reading them properly</td>
<td></td>
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<tr>
<td>o</td>
<td>Thermometers used by vendors are not able to be calibrated</td>
<td></td>
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<tr>
<td>o</td>
<td>Vendors are unaware of the requirements to use a thermometer</td>
<td></td>
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<tr>
<td>o</td>
<td>Vendors are unaware of how to properly use a thermometer</td>
<td></td>
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<tr>
<td>o</td>
<td>Other</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>o</td>
<td>I do not know</td>
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</tbody>
</table>

### 14. Food Identification

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Food properly labeled; original container</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Food items or packaging does not contain any required labeling or identification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Food items are mislabeled or missing required information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Food items are removed from their original containers and improperly re-packaged</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Vendors are unaware of proper labeling requirements for certain food items</td>
<td></td>
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<td></td>
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<tr>
<td>o</td>
<td>Other</td>
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<tr>
<td>o</td>
<td>I do not know</td>
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</tbody>
</table>

### 15. Prevention of Food Contamination

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Contamination prevented during food preparation, storage &amp; display.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Contamination is observed or likely during food preparation due to lack of glove use or no hand washing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Food items are stored or displayed improperly leading to potential cross-contamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Vendors are unaware of practices to prevent contamination during food preparation, storage, and display</td>
<td></td>
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<td></td>
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<tr>
<td>o</td>
<td>Other</td>
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<td>o</td>
<td>I do not know</td>
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</table>
### 16. Prevention of Food Contamination

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Personal Cleanliness</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>b. Most common reason(s) for non-compliance (mark all that apply):</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
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<td></td>
</tr>
<tr>
<td>○ Vendors clothing appears soiled or is dirty</td>
<td></td>
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</tr>
<tr>
<td>○ Vendors exhibit poor hygienic practices leading to an uncleanly appearance</td>
<td></td>
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<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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### 17. Proper Use of Utensils

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<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. In-use utensils; properly stored</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>b. Most common reason(s) for non-compliance (mark all that apply):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ In-use utensils are improperly stored leading to potential contamination of foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Vendors are unaware of proper methods to store in-use utensils</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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</tbody>
</table>

### 18. Proper Use of Utensils

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Gloves used properly</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>b. Most common reason(s) for non-compliance (mark all that apply):</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ If gloves are in use, they are not changed after touching raw foods and before RTE foods</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ If gloves are in use, they are not changed after handling money and before touching other foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ If gloves are in use, they are not changed after touching the face or body and before touching other foods</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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</tr>
</tbody>
</table>
### 19. Utensils, Equipment and Vending

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Food &amp; non-food contact surfaces cleanable, properly designed, &amp; used.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ Food &amp; non-food contact surfaces are made of material that is not cleanable (i.e. wood), and are not covered by a clean cloth or disposable clean covering.</td>
<td></td>
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<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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</tbody>
</table>

### 20. Food Employee Certification

<table>
<thead>
<tr>
<th></th>
<th>Almost Never &lt;5%</th>
<th>Rarely 5%-20%</th>
<th>Sometimes 20%-50%</th>
<th>Often 50%-80%</th>
<th>Usually 80%-95%</th>
<th>Almost Always &gt;95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Certification displayed properly and is up-to-date</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Most common reason(s) for non-compliance (mark all that apply):</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ I have never observed this inspection item to be <strong>Out of Compliance</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>○ If required, vendors do not have proper certifications</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>○ If required, vendors do not properly display certifications</td>
<td></td>
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</tr>
<tr>
<td>○ If required, vendors do not have up-to-date certifications</td>
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<td></td>
</tr>
<tr>
<td>○ Other</td>
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<tr>
<td>○ I do not know</td>
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</tbody>
</table>
# Appendix D. Pennsylvania Department of Agriculture Food Safety Inspection Report

## FOOD ESTABLISHMENT INSPECTION REPORT

<table>
<thead>
<tr>
<th>PENNSYLVANIA DEPARTMENT OF AGRICULTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2601 N CAMERON ST. HARRISBURG PA 17110</td>
</tr>
<tr>
<td>Phone 717-787-4315</td>
</tr>
</tbody>
</table>

### FOODBORNE ILLNESS RISK FACTORS AND PUBLIC HEALTH INTERVENTIONS

<table>
<thead>
<tr>
<th>Compliance Status</th>
<th>Compliance Status</th>
</tr>
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<tbody>
<tr>
<td>IN</td>
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</table>

#### Demonstration of Knowledge

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<table>
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<tr>
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<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
<td>IN</td>
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<td>4</td>
<td>IN</td>
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<td>5</td>
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#### Employee Health

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#### Good Hygienic Practices

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<tr>
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#### Preventing Contamination by Hands

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<tr>
<td>13</td>
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<td>14</td>
<td>IN</td>
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### Protected Source

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<tr>
<td>16</td>
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<td>17</td>
<td>IN</td>
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<td>18</td>
<td>IN</td>
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</table>

### Protection from Contamination

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### Preventing Food Contamination

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<td>23</td>
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### Good Retail Practices

Good Retail Practices are preventative measures to control the addition of pathogens, chemicals, and physical objects into foods.

### Safe Food and Water

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<td>25</td>
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### Food Temperature Control

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### Food Identification

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### Physical Facilities

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### Proper Use of Utensils

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### Utensils, Equipment and Vending

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### Food Establishment Inspection Report

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### Postscript

Risk factors are improper practices identified as the most prevalent contributing factors of foodborne illness or injury. Public Health Interventions are control measures to prevent foodborne illness or injury.
Appendix E

Farmers’ market manager structured group interview recruitment letter, consent form and question route
Appendix E. Farmers’ market manager structured group interview recruitment letter, consent form and question Route

Calling all farmers’ market managers in Pennsylvania!

We would like to formally invite you to attend a research, focus group interview for farmers’ market managers on farmers’ market food safety.

When: November 18th @ 11 AM

Where: Lehigh County Ag Center
4184 Dorney Park Road, Room 104
Lehigh County Agricultural Center
Allentown, PA 18104-5798

Details: We would like your voluntary participation in a 1-hour group interview. All participants will receive a $20 cash incentive at the time of the interview for their participation. Food and refreshments will also be served during the group interview session.

RSVP: Please RSVP to Bryan Moyer by phone or email no later than (Date TBD)

Brian F. Moyer
Program Assistant
Penn State Extension – Lehigh County
Phone: 610-391-9840
Email: bfm3@psu.edu

We look forward to hearing your thoughts, ideas, and opinions on food safety issues at farmers’ markets, and ways to keep farmers’ markets in Pennsylvania safe and thriving.

If you have any additional questions, please contact the lead researcher, Josh Scheinberg or Principle investigator Dr. Catherine Cutter.

Joshua Scheinberg
Ph.D. Candidate
Department of Food Science
Pennsylvania State University
Email: jas6387@psu.edu

Catherine N. Cutter, Ph.D.
Professor of Food Science
Department of Food Science
Pennsylvania State University
Email: cnc3@psu.edu

Please read on for more details on this study
Background:

Researchers at the Penn State Department of Food Science are exploring the possibility of developing training for farmers’ market vendors in food safety, regulations, and retail food service practices. Market managers have a unique and direct relationship with vendors who operate at their associated markets, and understand the constraints and needs of those vendors. In order to provide the very best of training, specifically tailored to the needs of Pennsylvania farmers’ market vendors, we would like to hear from market managers to get their feedback and ideas on these topics.

What do we want to do:

These researchers would like to hold a group interview with farmers’ market managers to create a dialogue and discussion in the areas of food safety at farmers’ markets, regulations, and vendor training.

What information will be collected?:

During the group interview session, a moderator will ask a series of questions to participants in order to create a dialogue and discussion on key topics related to farmers’ markets and food safety. All participant responses will be kept anonymous, and contact information will never be associated with a participant’s response. Each group interview session will be recorded, however recordings will only be accessible to these Penn State researchers, and never released to an outside party.

Do I have to sign anything?

Before your participation on the day and location of the group interview session, you will be provided with an informed consent form outlining the details of this project in which we will require your signature and consent. This will ensure you understand your role and your voluntary participation in this study. This research has been reviewed and approved by the Penn State Institutional Review Board. Please do not hesitate to contact us with any questions regarding your participation.
Title of Project: Structured group interview of farmers’ market managers in Pennsylvania

Principal Investigator: Dr. Catherine Cutter, 433 Food Science Building, University Park, Pa 16802 (814)-865-8862 cnc3@psu.edu

Other Investigator(s): Joshua Scheinberg, 431 Food Science Building, University Park, Pa 16802 jas6387@psu.edu
Robson Machado, 434 Food Science Building, University Park, Pa 16802 als5929@psu.edu

1. Purpose of the Study: The purpose of this research is to gather farmers’ market manager opinions, ideas, and feelings on farmers’ market food safety and future development of food safety training for farmers’ market vendors.

2. Procedures to be followed: You will be asked to participate in a 1 hour structured group interview, in which you will be asked to provide your opinions, ideas, and feelings on topics related to food safety, farmers’ market food safety, and best practices and methods for farmers’ market vendor training in a group discussion setting. The structured group interview may consist of 3-9 other farmers’ market managers who will also be participating in the group interview discussion at the same time. You will not be asked to provide any personal or identifying information, you may stop and leave the group interview at any time, and you may choose to NOT answer questions or provide feedback on any specific topics or questions.

3. Discomforts and Risks: There are no risks involved in this research, beyond those experienced in everyday life.

4. Benefits: The benefits to you include future invitations to farmers’ market related training and future access to informational materials in the areas of food safety and food production customized for farmers’ markets. The benefits to society include an overall safer food supply.

5. Duration/Time: The structured group interview will last a minimum of 30 minutes, but no more than 1 hour, depending on the level of participation and completion of the research goals, determined by the moderator.

6. Statement of Confidentiality: Your participation in this research is confidential. Your contact information will only be collected to provide you with the $20 cash incentive for your participation, and also if you choose be notified of future farmers’ market related training programs. Group interview discussions will be recorded by an audio recording device, and those recordings will be transcribed into text containing no personal participant identifying information. The audio recordings and transcriptions will be stored and secured at Penn State University in a locked file cabinet or on password-protected computer files. Only Dr. Catherine Cutter and Joshua Scheinberg will have access to the recordings and transcriptions, which will be kept secure for three years after the conclusion of the study. We expect to conclude this research by 2016. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The Pennsylvania State University's Office for Research Protections and Institutional Review Board, and
the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project. Your confidentiality will be kept to the degree permitted by the technology used.

7. **Right to Ask Questions:** Please contact Dr. Catherine Cutter at (814) 865-8862 or via email at cnc3@psu.edu with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University's Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

8. **Voluntary Participation:** Your decision to be in this research group interview is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

9. **Payment for Participation:** You will be compensated $20 for your participation, however your name, address, and phone number are required to receive this compensation. This information is only required for Penn State accounting purposes to show proof of receipt of the cash incentive. This information will be kept secure, will not be associated with your group interview responses, and NEVER released to any other party.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study given the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this consent form for your records.

__________________________________________________________________________  _____________
Participant Signature                  Date
Structured Group Interview Question Route

Farmers’ market managers will be asked the following questions throughout the structured group interview session, as time permits. The moderator may change the order of these questions if the discussion moves to these topics on its own.

Introduction:

Good morning, my name is Josh Scheinberg and I will be moderating this group discussion today. Thank you all for your time and for your participation in this ongoing study on farmers’ markets. In the past year, Penn State researchers went out to farmers’ markets across Pennsylvania and observed vendors at active markets, watching their food safety practices at the retail environment. These researchers also surveyed PDA inspectors to determine the most common issues facing farmers’ market vendors during their official inspections. Lastly, these researchers also surveyed farmers’ market vendors to explore their knowledge and attitudes on food safety related topics. After extensive analysis and review, the research group has determined that farmers’ market vendors would greatly benefit from food safety training, but before we delve into training development, we want your input and your ideas. As a market manager you have a unique role and relationship with the vendors at your market, and through this discussion today, we hope to hear your opinions, feelings, and ideas on topics related to food safety at farmers’ markets.

In the next hour, I will ask questions to you as a group. I would like to hear from everyone in the group, so I would please ask that you be respectful to others in this group, allow everyone a chance to talk, and please do not talk over others while they are talking.

I also want to remind everyone that this conversation is being recorded, however your responses will not be associated with your identity, and any contact information collected from you is kept confidential.

Are there any questions before we begin?

Questions:

1.) Let’s go around the group, and if you feel comfortable please describe your experience as a market manager.

2.) In your opinion, what is the role of the farmers’ market manager?

3.) Do you think food safety is something to worry about at farmers’ markets?

4.) During the vendor observations that we described before, our researchers saw that a majority of the time, vendors were not washing their hands when they should have. The PDA inspectors which were surveyed also noticed a similar trend, and many times saw that vendors did not have adequate hand-washing facilities available. Alternatively, a majority of the surveyed vendors reported that they do wash their hands when they are supposed to, and if they don’t have a hand washing station, it is because they are not required to have one at the market.
When it comes to hand washing and providing hand washing stations at the farmers’ market, why do you think there is a difference between what our researchers and PDA inspectors see, versus what the vendors say they are doing?

5.) During those same vendor observations, our researchers saw that a majority of the time, vendors who used cold or hot storage containers at the market, did not have a thermometer present in order to check temperatures of foods held in those containers. The PDA inspectors surveyed also saw that during their inspections, more often than not, thermometers were not present or accurate when they were required. Alternatively, a majority of the vendors surveyed reported that if they stored foods which required cold or hot storage at the market, then they were using a thermometer to verify proper cold or hot storage temperatures.

When it comes to thermometer use at the market, why do you think there is a difference between what our researchers and PDA inspectors see, versus what the vendors say they are doing?

6.) What are your thoughts and opinions on providing food safety training to vendors, and if you had to develop a program, how would you deliver the training, and what kinds of key areas would you cover?

7.) The results from our research, including vendor observations, PDA inspector surveys, and vendor surveys have identified clear gaps in vendor knowledge on food safety and found several improper food safety behaviors at the retail environment. Some of these gaps include: when to wash hands and its importance, proper raw food handling, thermometer use, and basic hygiene of a food retailer. Based on your experiences and observations at farmers’ markets, do you think vendors need or should be trained in some manner on food safety, and are there any specific areas that you think should be a focus of this training?

8.) Since vendors may only be inspected once a year, what are your thoughts on the role that market managers currently or could play in monitoring food safety practices at the market?

9.) What are your thoughts and opinions on providing food safety training to vendors using either a web-based program which is self-run, self-paced, produces a certificate of completion, and requires no formal instruction, or a flip book style training (show example), which you as a market manager could present to your vendors, which also requires no prior knowledge or background in food safety?

Optional follow up: If you do feel that market managers could serve a role in providing food safety training to vendors, would you feel most comfortable in delivering training through a table-top flip book, self-run PowerPoint on a laptop, self-run web-based training, or (insert other idea proposed by group).

Optional follow up: How much time would you be willing to give up to present this training, 1 hour, 2 hours, or multiple sessions?
10.) Considering what was discussed today, if you had the ability to change or fix something about food safety at Pennsylvania farmers’ markets, what would it be and how do you think you would do it?

Follow up: Have I missed anything or does anyone have anything else to say?
Appendix F

Number of samples purchased and tested positive for *Escherichia coli*, *Listeria* spp., and *Listeria monocytogenes* among sampled farmers’ market vendors
Appendix F: Number of samples purchased and tested positive for *E. coli* (EC), *Listeria* spp. (LIS) and *L. monocytogenes* (LM) among sampled farmers’ market vendors.

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Appendix G
Farmers’ market vendor food safety pilot training program knowledge and attitude assessment and consent form
Appendix G. Farmers’ market vendor food safety pilot training program knowledge and attitude assessment and consent form

Title of Project: Farmers’ Market Food Safety Knowledge and Attitude Assessment

Principal Investigator: Dr. Catherine Cutter, 433 Food Science Building, University Park, Pa 16802, (814)-865-8862 cnc3@psu.edu

Other Investigator(s): Joshua Scheinberg, 431 Food Science Building, University Park, Pa 16802, jas6387@psu.edu

1. **Purpose of the Study:** The purpose of this research is to evaluate the knowledge and attitudes of farmers’ market vendors before and after a 3-hour farmers’ market food safety training program.

2. **Procedures to be followed:** You will be asked to complete the same questionnaire (consisting of 26 questions) before and after the 3-hour training session. There is no time limit, you may skip questions, and can stop at any time.

3. **Discomforts and Risks:** There are no risks involved in this research, beyond those experienced in everyday life.

4. **Benefits:** The benefits to you include improvement in future farmers’ market vendor food safety training and access to informational materials in the areas of food safety and food production customized for vendors who produce foods sold at farmers' markets. The benefits to society include an overall safer food supply.

5. **Duration/Time:** The questionnaire will take approximately 15-20 minutes to complete.

6. **Statement of Confidentiality:** Your participation in this research is confidential. The data from this questionnaire will be aggregated, stored and secured at Penn State University in a locked file cabinet or on password-protected computer files. Only Dr. Catherine Cutter and Joshua Scheinberg will have access to the data. Digital data (tabulated data from questionnaires) will be kept for three years after the conclusion of the research. We expect to conclude the research by 2016. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The Pennsylvania State University's Office for Research Protections and Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project. Your confidentiality will be kept to the degree permitted by the technology used.
7. **Right to Ask Questions:** Please contact Dr. Catherine Cutter at (814) 865-8862 or via email at cnc3@psu.edu with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University's Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

8. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

9. **Payment for Participation:** There is no additional payment or incentive for completing the questionnaire.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study given the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this consent form for your records.

__________________________________________________________________________  __________
Participant Signature                     Date
Section 1: Knowledge Assessment

The following questions will test your knowledge on several food safety-related topics. Answer each question to the best of your ability, and please attempt to answer each question. If you don’t know an answer, choose “I do not know” or write your response next to the question.

1.) For the following objects listed below, identify if they are chemical, physical, or biological hazards and if they are present in food.

Instructions: Circle “Physical”, “Chemical”, or “Biological” next to each of the objects below. If you do not know the answer, circle “I don’t know”.

<table>
<thead>
<tr>
<th>Object</th>
<th>Hazard</th>
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<tbody>
<tr>
<td>Example: E. coli:</td>
<td>Physical Chemical Biological I do not know</td>
</tr>
<tr>
<td>a) Metal shavings:</td>
<td>Physical Chemical Biological I do not know</td>
</tr>
<tr>
<td>b) Leached copper:</td>
<td>Physical Chemical Biological I do not know</td>
</tr>
<tr>
<td>c) Listeria monocytogenes:</td>
<td>Physical Chemical Biological I do not know</td>
</tr>
<tr>
<td>d) Oil lubricant:</td>
<td>Physical Chemical Biological I do not know</td>
</tr>
<tr>
<td>e) Campylobacter spp.:</td>
<td>Physical Chemical Biological I do not know</td>
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</tbody>
</table>

2.) Which is a bacteria that is found naturally in the human nose and can contaminate foods from sneezing, coughing, or someone touching their nose and then touching foods? (Circle your answer)

a. Salmonella typhi  
b. Staphylococcus aureus  
c. Campylobacter jejuni  
d. Chicken pox  
e. Choices A and C  
f. All of the above  
g. I don’t know
3.) Which of the following is NOT a “FATTOM” parameter and is NOT important with regard to growth of foodborne pathogens in food? (Circle your answer)

   a. Acidity  
   b. Time  
   c. Temperature  
   d. Moisture  
   e. Texture  
   f. I do not know

4.) Which of the following would be considered a BAD hygiene behavior during food preparation or sale at the market? (There may be more than one answer, circle all that apply)

   a. Washing your hands after touching raw meat  
   b. Wearing a hairnet, hat, or hair covering  
   c. Eating while preparing food  
   d. Sneezing into your hands and wiping it on your clothes  
   e. All of the above  
   f. I do not know

5.) Which of the following three factors are important when using sanitizers? (Circle your answer)

   a. Concentration, water activity, contact time  
   b. Concentration, viscosity, temperature  
   c. Concentration, temperature, contact time  
   d. Concentration, acidity, temperature  
   e. Concentration, corrosiveness, temperature  
   f. I do not know

6.) Dirty utensils should be sanitized before they are cleaned? (Circle your answer)

   a. True  
   b. False  
   c. I do not know
7.) Which of the following is a time-temperature control for safety (TCS) food? (Circle your answer)
   a. Washed shell eggs
   b. Sliced leafy greens
   c. Raw Sprouts
   d. Deli meat
   e. Both a and d
   f. All of the above
   g. I do not know

8.) Which of the following represents the “temperature danger zone,” which is the temperature range for rapid bacterial growth? (Circle your answer)
   a. Between 51°F and 135°F
   b. Between 35°F and 135°F
   c. Between 0°F and 135°F
   d. Between 40°F and 140°F
   e. Between 51°F and 145°F
   f. I do not know

9.) What is the proper temperature to store fresh, whole raw chicken, milk, or sliced leafy greens? (Circle your answer)
   a. Below 51°F
   b. Below 135°F
   c. Below 40°F
   d. Below 45°F
   e. Below 70°F
   f. I do not know

10.) An acceptable measure of doneness when cooking hamburgers is when the color changes from red to brown. (Circle your answer)
    a. True
    b. False
    c. I do not know

11.) Thermometers used daily only have to be calibrated every few months. (Circle your answer)
    a. True
    b. False
    c. I do not know
12.) After which activity should thermometers be washed, rinsed, and sanitized?  
(There may be more than one answer, circle all that apply)

   a. When the thermometer has been used and set down on an un-sanitized surface  
   b. When the thermometer has been used on raw foods and before using it for cooked foods  
   c. Once every hour, regardless of how it is used  
   d. Thermometers aren’t designed to be washed and sanitized  
   e. All of the above  
   f. I don’t know

13.) Which is an example of potential cross-contamination at the farmers’ market?  
(There may be more than one answer, circle all that apply)

   a. Handling un-packaged raw meat, then handling raw produce (no hand washing in between)  
   b. Un-packaged raw meats stored in the same deli case or cooler as unpackaged cooked deli meat  
   c. Using the same tongs for handling both raw and cooked foods  
   d. Eggs and milk stored in the same cooler  
   e. All of the above  
   f. I do not know

14.) Which is NOT a benefit to using pre-packaging for foods sold at farmers’ markets?  
(Circle your answer)

   a. Eliminates the need for good hygiene practices  
   b. Reduces the risk of cross contamination  
   c. Decreases the chance a customer might contaminate your food products  
   d. Provides a surface for labeling  
   e. Both b and d  
   f. All of the above  
   g. I do not know

15.) Which of the following are situations where you would need to wash your hands at the farmers’ market? (There may be more than one answer, circle all that apply)

   a. After handling raw meat and before touching fresh spinach  
   b. After handling a head of lettuce and before handling fresh spinach  
   c. After handling money and before slicing deli meat  
   d. Before putting on disposable gloves to handle raw meat  
   e. All of the above  
   f. I do not know
Section 2: Attitude Assessment

Instructions: For the following questions, circle the number which represents how important you feel about each question.

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(Circle your choice under each question)

Hygiene
How important is practicing good hygiene habits when preparing and selling food at the farmers’ market?

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Hand Washing
How important is practicing proper hand washing habits when preparing and selling food at the farmers’ market?

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Cross Contamination
How important is preventing cross contamination while preparing and selling food at the farmers’ market?

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**Thermometer Use**
How important is it to use a calibrated thermometer while preparing and selling TCS foods at the farmers’ market?

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**Food Safety Hazards**
How important is it to understand food safety hazards while preparing and selling food at the farmers’ market?

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**Section 3: Demographic Assessment**

1. What is your age? *(Circle your answer)*
   
   a. 18-21
   b. 22-34
   c. 35-44
   d. 45-54
   e. 55-64
   f. 65 and over
   g. I do not wish to answer

2. What is your gender? *(Circle your answer)*
   
   a. Male
   b. Female
   c. Other (please specify) ________________
   d. I do not wish to answer

3. How would you describe yourself? *(Circle your answer)*
   
   a. Black/African American
   b. Hispanic
   c. White (Non-Hispanic)
   d. Other (Please Specify)_________________________
   e. I do not wish to answer
4. Have you ever taken any food safety classes? (Circle your answer)
   a. Yes
   b. No
   c. I do not know

5. What is the highest degree or level of school you have completed? If currently enrolled, mark the previous grade or highest degree received? (Circle your answer)
   a. No formal schooling completed
   b. Elementary school (1st to 6th grade)
   c. Middle School (6th to 8th grade)
   d. Attended high school, but did not graduate
   e. High school graduate (or completed GED)
   f. Some college credit, but less than 1 year
   g. 1 or more years of college, no degree
   h. Associate degree
   i. Bachelor’s degree
   j. Master’s degree
   k. Doctoral degree
   l. I do not wish to answer

6. How many years have you been farming and/or processing foods specifically for sale at farmers’ markets? (Circle your answer)
   a. Less than 1 year
   b. 1-2 years
   c. 2-3 years
   d. 3-4 years
   e. 4-5 years
   f. More than 5 years
   g. I do not know
   h. I do not wish to answer
Appendix H

Farmers’ market food safety pilot training resource guide
The Farmers’ Market Food Safety Resource Guide

Pennsylvania State University
College of Agricultural Sciences
Department of Food Science

Penn State Extension
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TCS Foods
Food Contact Surfaces
Regulations

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Appendix 2: Methods for Calibrating Thermometers
Chapter 1: Farmers’ Markets and Foodborne Illness - Understanding the Risks

Introduction:
Ensuring the safety of food is one of the most important responsibilities for anyone who harvests, processes, prepares and/or sells food. It is not only important for public health, but also for the livelihood of those tasked with bringing that food to market. As a food producer or consumer, it is important to understand that contamination of food can occur anywhere within the food production chain. As food operations become more complex, so do the food safety challenges. This concept is illustrated in the figure below.

Figure 1: As farmers or small food processors move from producing raw commodities with minimal processing, to Time/Temperature Control for Safety (TCS) foods and RTE foods which require more complex food processing, the potential for food safety risks increase.

Unlike traditional food retail establishments, producing and selling food for sale at farmers’ markets comes with its own unique set of challenges. Farmers’ markets not only provide farmers and small food processors a unique opportunity to sell food direct to consumers, but also operate in a variety of challenging environments. It is because of these unique features, that farmers and food processors producing food for sale at farmers’ markets be knowledgeable of food safety risks and understand how to control them during the preparation, processing, and sale of those food items.

Through the next seven chapters, food safety risks associated with farmers’ markets will be explored and key concepts and practices will be discussed. Specifically the following topics will be covered:
Foodborne illness:

The CDC estimates that each year, 48 million people will become ill from eating food, 300,000 will be hospitalized, and 3,000 will die. The risk of foodborne illness can arise anywhere along the food chain, from the time that raw foods are harvested, through processing and sale, until the time it is prepared and handled by the consumer. Farmers’ markets are part of this chain and are not exempt from the risk of food contamination.

Overall, there have not been a large number of reported cases of foodborne illness associated with food sold at farmers’ markets (See Table 1.1). However it is important to note that not all cases that occur are reported, and furthermore, many do not result in what is called an outbreak. For a contamination event to be called an outbreak, two or more people have to get sick from that same food, and that food must be shown to contain the harmful contaminant. In general, most cases of foodborne illness that occur in the United States are considered sporadic – such as a single case of foodborne illness, an unreported case, or cases where the cause is not identified.

Table 1.1: Foodborne Illness and Outbreaks Associated with Farmers’ Markets in the U.S.

<table>
<thead>
<tr>
<th>Year</th>
<th>State</th>
<th>Issue</th>
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<tbody>
<tr>
<td>2014</td>
<td>Michigan</td>
<td>STEC E. coli outbreak associated with apple cider (4 ill), vendor convicted of willful misbranding and adulteration of food products</td>
</tr>
<tr>
<td>2014</td>
<td>California</td>
<td><em>Salmonella</em> outbreak associated with cheese (14 ill)</td>
</tr>
<tr>
<td>2012</td>
<td>Pennsylvania</td>
<td><em>Campylobacter</em> outbreak associated with raw milk sold (38 ill)</td>
</tr>
<tr>
<td>2011</td>
<td>Oregon</td>
<td>STEC E. coli outbreak associated with strawberries (16 ill, 1 death)</td>
</tr>
<tr>
<td>2010</td>
<td>Iowa</td>
<td><em>Salmonella</em> outbreak associated with guacamole, salsa and tamales (25 ill)</td>
</tr>
<tr>
<td>2008</td>
<td>Alaska</td>
<td><em>Campylobacter</em> outbreak associated with raw peas (18 ill)</td>
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Not all cases of contamination necessarily lead to foodborne illness. In some cases, the contamination level may be too low, and the person’s natural defense systems, including the immune system, are able to fight off the illness. There are, however, populations who are considered high risk for contracting foodborne illness.

These groups include:

- Elderly whose immune systems weaken as they age.
- Infants and preschool-aged children who do not have strong immune systems.
- People who are on certain medications that hamper the immune system, including people on cancer treatment medication.
- People who have an illness that impairs the immune systems, such as those with AIDS.
• Woman who are pregnant and their fetuses, since the immune system has been suppressed to some degree.

The costs of foodborne illness:

Those customers who visit farmers’ markets encompass the whole spectrum of people, and because of this issue, vendors must do everything they can to guard against contamination.

If a case of foodborne illness should arise, it is not only a tragedy for the people who become ill, but also can have a devastating impact on the responsible parties. Doctors’ bills or lost wages are just some of the costs that can be assessed during litigation, and these costs can run much higher, depending on the severity of the illness and the number of people that become ill. During a lawsuit, jurors also may award the injured party thousands to millions of dollars beyond the medical costs. If a vendor is found negligent, fines can be assessed, as well as the potential for jail time.

A case in point was a multi-state *Listeria* outbreak in 2011 associated with cantaloupes grown on a Colorado farm. Contaminated cantaloupes caused a total of 139 illnesses and 29 deaths. Consequently, the farmer and family lost their farm and packing operation, which were businesses that had been in the family for three generations.

Media exposure that often follows in the wake of large outbreaks can impact negatively the business in terms of lost sales, in both the short term as well as in the long term. It can be difficult for companies to regain public trust after being involved in an outbreak and sales will drop as people avoid the potential risk. It can be difficult to regain trust of the public, and businesses may take years to recover.

Not only is the responsible vendor’s business at risk when an outbreak occurs, but reports of a foodborne illness can impact the entire farmers’ market, along with the network of vendors represented there. News reports may not detail who was responsible for selling the contaminated food, but rather only where the food was purchased, such as a participating farmers’ market. With or without that detail of the individual vendor, people may avoid that farmers’ market altogether.

Negative media exposure following a 2006 multi-state outbreak of Shiga-toxin producing (STEC) *E. coli* originating from spinach grown in California, resulted in millions of dollars in losses suffered by the entire spinach industry. Although the contaminated spinach was traced to one farm, consumers stopped buying spinach all together. Five years after the outbreak, sales of California spinach still lag behind pre-outbreak levels.

For the health of the business and the customers they serve, vendors must have an understanding of food safety related contaminants, how they get into food, and what controls can be put into place to prevent those contaminants from causing illness. Let’s now discuss the specifics of these points.

**The Three Types of Contaminants, Sources, and Controls**

Food contaminants, also known as food hazards, can be categorized into three types – physical, chemical, and biological.

**Physical Contaminants**

Physical contaminants include items such as glass shards, metal shavings, and hard plastic pieces (See Table 1.2). These are objects that can cause injury when consumed. Injury may include cuts to the
mouth, choking, or lacerations in the digestive tract. With certain items, even teeth can be cracked or broken.

Some of these physical items get into the food accidentally, such as from a piece of faulty equipment. For example, metal shards can be generated from a blade in a food mixer. Physical contaminants can come from packaging materials, such as metal pieces from the lid of a can when the can opener is not properly sharpened.

Table 1.2: Physical Contaminants Associated with Food Production

<table>
<thead>
<tr>
<th>Item</th>
<th>Source (examples)</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass pieces</td>
<td>Glass used in operations and glass packaging.</td>
<td>• Remove glass from operation where possible.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use shatter resistant glass or plastic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cover glass with plastic film.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use shields on glass bulbs and heat lamps.</td>
</tr>
<tr>
<td>Metal shavings, screws, bolts, staples</td>
<td>Equipment with metal-on-metal contact, poorly operating equipment, and staples used on boxes.</td>
<td>• Inspect equipment and ensure proper equipment operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Visually inspect items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use metal or x-ray detection devices.</td>
</tr>
<tr>
<td>Personal items including jewelry and pens</td>
<td>Personnel wearing jewelry or storing items in shirt pockets while working with food.</td>
<td>• Do not permit employees to wear exposed jewelry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Do not place items in pockets above the waste.</td>
</tr>
<tr>
<td>Rocks and sticks in field crops</td>
<td>Items that are collected along with food during harvest.</td>
<td>• Inspect incoming materials.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure harvester is using GAPs.</td>
</tr>
<tr>
<td>Plastic</td>
<td>Plastic ties, plastic containers, and plastic gloves.</td>
<td>• Ensure plastic is removed and properly disposed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Retire any well-worn or cracked plastic containers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Replace torn or ripped gloves.</td>
</tr>
<tr>
<td>Pits and pit pieces</td>
<td>Stone fruit.</td>
<td>• Remove pits.</td>
</tr>
</tbody>
</table>

Controlling and preventing accidental contamination is accomplished by adherence to procedures designed to prevent items from getting into the food. For example, having shields on glass bulbs to prevent broken glass from falling into the product, following personal hygiene programs that prevent ink pens or jewelry from accidently being dropped into food, and preventive maintenance to prevent loose bolts or metal shavings from getting into the food.

In other cases, the physical contaminant may be a natural part of the food that is not properly removed. For example, a cherry pit that winds up in a cherry pie, or a piece of bone that was not properly removed from a chicken soup product. These types of hazards are controlled by ensuring processes are in place for removal. If ingredients are purchased, then a supplier agreement should be in place to ensure that the supplier has processes which are implemented, such as pit removal, and that those processes are monitored to ensure compliance.
**Chemical Contaminants**

Chemical contamination of food can occur throughout the food chain. Some chemicals can be naturally associated with a food, while others get into the food, either through misapplication, such as too much of a chemical being added, or through accidental addition (See Table 1.3).

**Mycotoxins** – There are some chemical contaminants that are naturally associated with the food or the ingredients and could be present before the food is processed. One important category of naturally-occurring contaminants is mold toxins, or mycotoxins. These compounds occur when the food or food ingredient has been subject to mold growth, which may occur if pre or post-harvest conditions allow mold to grow. Aflatoxin is a very dangerous mycotoxin found in corn. Patulin is a mycotoxin that can be found in rotting apples. Mycotoxins are very dangerous, can be carcinogenic or mutagenic, and can cause liver damage by those individuals who consume them.

To control mycotoxins it is important to know which food or ingredients are subject to mold growth. For grain crops, mycotoxins should be managed by the harvester/miller, and fruit crops with mold should be screened out with a culling step by the grower/producer.

**Allergens** – Allergens are specific proteins that cause an abnormal immune response in people who are sensitive to them. While there are over 160 known allergenic compounds, in the U.S. there are regulations requiring the identification and labeling of eight allergen groups. These groups include peanuts, tree nuts, crustacean shellfish, fish, dairy, wheat, soy, and eggs.

It is estimated that 2 to 4 percent of adults and 6 to 8 percent of children have food allergies. Because of these issues, it is important that the eight groups of allergens be properly identified in the products in which they are used.

**Pesticides** – Pesticides incorporate a large number of compounds that are used to control pests in the field, as well as after harvest. The application of pesticides are regulated by the U.S. Environmental Protection Agency (EPA). Anyone spraying chemicals must have a license and keep records of pesticide use. For facility application of pesticides in food processing environments, it is important that these chemicals are applied by a licensed pest control operator. There are many restrictions on the types of chemicals that can be applied. For further information, contact your local and/or state sanitarian.

**Cleaners and sanitizers** – Cleaners and sanitizers are used throughout food processing operations, especially those residual chemicals that may be left on the equipment after the sanitation process is complete. Using sanitation chemicals at the same time food also is being handled or prepared, presents another opportunity for contamination when those chemicals are accidently spilled into food or in food processing areas.
### Table 1.3: Chemical Contaminants Associated with Food Production

<table>
<thead>
<tr>
<th>Item</th>
<th>Source</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticides</strong></td>
<td>Field application</td>
<td>• Farmer has pesticide applicator permit and follows approved practices.</td>
</tr>
<tr>
<td></td>
<td>Operation application</td>
<td>• Contract a certified Pest Control Operator.</td>
</tr>
</tbody>
</table>
| **Mycotoxins**   | Incoming grains         | • Crops are monitored for conditions that will support mold growth.  
|                  |                         | • Grains must be tested as needed.            |
|                  | Fruit and vegetables    | • Exclude dropped fruit.                      |
|                  |                         | • Remove fruits and vegetables that are moldy, diseased, or bruised heavily. |
| **Sanitation chemicals** | Usage                  | • Follow established procedures for application of cleaning and sanitizer chemicals.  
|                  |                         | • Measure sanitizer concentrations.           |
|                  | Residual on equipment   | • Inspect equipment prior to production.      |
| **Maintenance chemicals** | Equipment leaks         | • Use food grade chemicals on equipment where food contact is possible. |

The use of cleaning chemicals should be restricted to certain employees who are authorized to do so and used only at certain times. Ensure that all chemicals used in a food production establishment are properly labeled so that chemicals are not used inadvertently in place of a food ingredient. When using chemicals, controls must be in place to ensure that the proper chemicals are used in the proper concentrations. When cleaning chemicals are used during sanitation operations, ensure that the operation is void of any pooling of chemicals.

**Other Chemicals** – A number of different chemicals could pose issues for contamination. These compounds include maintenance chemicals, such as lubricants and solvents, water treatment chemicals, or other chemicals needed for normal operation of the food establishment. It is important that these chemicals are marked and stored properly in a secure location. When chemicals are in use, control must be taken so that they do not contaminate food or food contact surfaces.

**Biological Contaminants**

Contamination of food by biological contaminants can occur due to a number of reasons such as undercooking, improper cooling, or poor personal hygiene. In general, many of the processes and procedures used during the handling and preparation of food are performed specifically to control certain biological contaminants. There are four main groups of biological contaminants which are known to be present in food and can cause illness or referred to as pathogenic – bacteria, viruses, parasites, and mold. Table 1.5 lists the primary pathogens associated with food.

While any food has the potential to be the source of biological contaminants, there are two special categories of foods which are at the highest risk of causing illness due to biological contaminants and require special handling:

- Ready-to-Eat (RTE) foods
- Temperature Control for Safety (TCS) foods
**RTE foods** are those foods that will be sold or served to a customer and consumed without any further preparation by that consumer. Examples include sliced fruit, deli sandwiches, fresh pressed juice, and bakery items. The type of pathogens of concern include those that can cause illness when present at low levels. These pathogens are said to have a low infectious dose. Such organisms include viruses, such as hepatitis A and norovirus, as well as bacteria, such as *Salmonella* and Shiga-Toxin Producing (STEC) *E.coli*.

When handling and preparing RTE foods, care must be taken to prevent contamination, since there will be no other processes in place (i.e. cooking) to eliminate any pathogens present on the food before it is consumed.

**TCS foods** are those foods that can support the growth of pathogenic bacteria and require temperature control to prevent pathogen growth.

To control bacterial growth in TCS foods, one must understand and use procedures to control the parameters needed for pathogen survival and growth.

These parameters are described using the acronym **“FATTOM”**, which stands for Food, Acidity, Temperature, Time, Oxygen, and Moisture

**Food** – Food must have the nutrients (protein and carbohydrates) to allow microorganism growth.

**Acidity** – Foods that are too acidic (pH ≤4) typically will not support the growth of pathogens. However, foods in the mid-pH range (pH 4.6 to 7.5) may support them, including items such as meat and milk. The pH scale is described in more detail below.

**Temperature** – The temperature range where pathogenic bacteria grow best is designated as the **temperature danger zone (TDZ)**, which is between 41°F and 135°F. The temperature range considered to have the highest risk for pathogenic bacteria growth is between 70°F and 125°F. Most of our standard control procedures (i.e. freezing, chilling, cooking) for preventing pathogenic bacteria growth are based upon these temperature ranges.

**Time** – Putting food into the TDZ does not mean the food will become “temperature abused” immediately. Microorganisms need a sufficient amount of time to grow at a given temperature.

**Oxygen** - The oxygen level has an impact on the types of microorganisms that can grow. The biggest issue with foods is when oxygen is not present (anaerobic) or present at very low levels. Under these conditions, certain pathogenic bacteria, such as *Clostridium botulinum*, can outcompete harmless spoilage microorganisms and grow and produce toxins.

**Moisture** – The more moisture that is present in the food, the more likely that food will support the growth of pathogens. The term Food Scientists use to describe moisture in food is called water activity (Aw). This term refers to the moisture in food which is available for microorganisms to use and grow. There are certain foods, like honey, that have moisture, but because that moisture is bound by the sugar molecules, it is not available to microorganisms for growth. Water activity is described in more detail below.

**pH** – pH describes the acidity (less than pH 7.0) or the alkalinity (greater than pH 7.0) of a food or solution. The pH scale ranges from 1-12, where a pH of 1-6 is considered acidic, a pH of 7 is neutral, and
a pH of 8-12 is alkaline. Pathogenic bacteria grow well between a pH of 4.6 and 7.5, and therefore the pH of a food can be used to control the growth of microbial pathogens.

**pH scale:**

```
1  2  3  4  5  6  7  8  9  10  11  12  13  14
-----acid-----neutral---alkaline----
```

**Water activity (Aw)** – Water activity is a term, with a value between 0 and 1, which indicates the level of available water in a food which is free for use by living organisms, such as bacteria. Water activity is not the same as the amount of water or moisture in a food. Water present in food can be chemically bound by proteins, carbohydrates, or other components, which is referred to as bound water. Microorganisms vary in the level of available or free water they require for growth, and therefore water activity like pH, can be used to control the growth of microbial pathogens in food.

**Table 1.4: Water Activity (Aw) of Common Foods.**

<table>
<thead>
<tr>
<th>Water Activity (Aw)</th>
<th>Food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostly Free</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>Distilled water</td>
</tr>
<tr>
<td>0.95</td>
<td>Fresh fruits and vegetables, meat, and fish</td>
</tr>
<tr>
<td>0.85</td>
<td>Juice concentrate, dry cheese, and margarine</td>
</tr>
<tr>
<td>0.70</td>
<td>Peanut Butter</td>
</tr>
<tr>
<td>Mostly bound</td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>Rolled oats, jellies, and jams, molasses, and nuts</td>
</tr>
<tr>
<td>0.60</td>
<td>Dried fruits, caramel, toffee, and honey</td>
</tr>
<tr>
<td>Less than 0.60</td>
<td>Beef jerky, noodles, spices, cookies, crackers</td>
</tr>
</tbody>
</table>

Foods that meet FATTOM conditions will support the growth of pathogenic bacteria, and will require special storage and handling procedures to limit microorganism growth or toxin production. The lists below are common foods that meet these conditions and thus, are categorized as TCS foods.

**These TCS foods must meet temperature control requirements to ensure their safety:**

- Raw meat (Beef, pork, goat, lamb, venison)
- Raw poultry (chicken, turkey, other fowl)
- Seafood (fish, shellfish, other seafood)
- Raw and Pasteurized dairy products (milk, cheese, yogurt)
- Deli meats
- Washed shell eggs
- Certain sliced fruit and vegetables (leafy greens, tomatoes, cantaloupe, melon)
- Raw sprouts
- Cooked vegetable foods (potatoes, rice, and others)
### Table 1.5: Biological Contaminants Associated with Food Production

<table>
<thead>
<tr>
<th>Organism</th>
<th>Food types involved in outbreaks</th>
<th>Risk factors</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella spp. (Bacteria)</td>
<td>Meats, poultry, eggs, milk and dairy products, fish, shrimp, spices, peanut butter, cocoa, chocolate, and produce (fruits and vegetables, such as tomatoes, peppers, and cantaloupes).</td>
<td>• Is widespread in nature, carried in intestinal track of many animals.</td>
<td>• Heat treatment, such as cooking of food.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Has low infectious dose and can cause disease, even if in low numbers.</td>
<td>• Reduce prevalence in raw meat and poultry through pre-harvest and post-harvest interventions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can survive in low moisture foods and dry foods and has increased heat resistance.</td>
<td>• Prevent cross contamination when working with source foods, including raw meat and poultry.</td>
</tr>
<tr>
<td>Campylobacter jejuni (Bacteria)</td>
<td>Improperly handled or undercooked poultry products, unpasteurized (raw) milk and cheeses made from unpasteurized milk, and contaminated water.</td>
<td>• Raw poultry lacking sufficient processing interventions can have high levels.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduce prevalence on poultry through processing interventions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prevent cross contamination when handling raw poultry.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pasteurize dairy products.</td>
<td></td>
</tr>
<tr>
<td>Escherichia coli (STEC) (Bacteria)</td>
<td>Raw or undercooked ground beef and beef products, raw milk, unpasteurized fruit juices, and leafy greens exposed to animal feces.</td>
<td>• Has low infectious dose and can cause disease, even if in low numbers.</td>
<td>• Reduce prevalence on beef carcasses and on beef trim destined for grinding through interventions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can survive in slightly acidic foods like apple juice.</td>
<td>• Prevent cross contamination to other foods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduce prevalence on beef carcasses and on beef trim destined for grinding through interventions.</td>
<td>• Cook beef to proper temperature.</td>
</tr>
<tr>
<td>Listeria monocytogenes (Bacteria)</td>
<td>Raw milk or inadequately pasteurized milk, chocolate milk, cheeses (particularly soft cheeses), ice cream, raw vegetables, raw poultry and meats (all)</td>
<td>• Can grow at refrigerated temperatures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Environmental contaminate in processing facilities with excessive moisture.</td>
<td>• Proper sanitation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minimizing moisture.</td>
<td>• Monitoring and prevention of cross contamination.</td>
</tr>
</tbody>
</table>
| **Staphylococcus aureus** (Bacteria) | Temperature-abused, cooked meat and poultry products; salads, such as egg, tuna, chicken, potato, and macaroni; bakery products, such as cream-filled pastries, cream pies, and chocolate éclairs; sandwich fillings; and milk and dairy products; breading and batter used to make fried foods. | • Is widespread, but commonly found on people’s skin and in nasal passages.  
• Grows to high numbers in temperature-abused cooked products and produces a heat stable enterotoxin that causes disease.  
• Once toxin is formed, it cannot be eliminated by cooking. | • Practicing good personal hygiene.  
• Using proper cooling methods for cooked meat products.  
• Storing foods at the proper temperatures. |
| **Clostridium botulinum** (Bacteria) | Improperly processed, home low acid canned foods; temperature-abused, cooked foods, such as soups and stews, and ROP packaged foods. | • Forms heat-resistant spores that can survive normal cooking conditions.  
• Does not grow below pH of 4.6.  
• Is anaerobic (grows in absence of oxygen.  
Some strains can grow at a temperature as low as 37°F | • Proper cooling of cooked foods.  
• Follow scientifically developed recipes for home food preservation. |
| **Clostridium perfringens** (Bacteria) | Temperature-abused, cooked foods, such as soups and stews, as well as cooked meat products. | • Organism survives cooking process and grows quickly at elevated temperatures. | • Cool cooked foods quickly.  
• Store cooked foods at proper temperatures. |
| **Norovirus** (Virus) | RTE foods, produce, shellfish, and food exposed to sick individuals through vomit or feces. | • Highly contagious and can spread rapidly from exposure to vomit or feces of sick individuals. | • Prevent sick individuals from working with or around food.  
• Purchase shellfish from approved suppliers. |
<table>
<thead>
<tr>
<th>Pathogen Type</th>
<th>Pathogen Details</th>
<th>Prevention Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hepatitis A (Virus)</strong></td>
<td>Raw produce, contaminated drinking water, raw shellfish, foods in contact with infected individuals.</td>
<td>• The virus is spread through water contaminated with feces from infected individuals; foods in contact with contaminated water can harbor the virus.</td>
</tr>
<tr>
<td><strong>Trichinella spiralis (Parasite)</strong></td>
<td>Raw or undercooked pork, boar, and other animals infected with the parasite.</td>
<td>• The parasite survives in the intestines of animals. • Is not spread from person to person.</td>
</tr>
<tr>
<td><strong>Giardia duodenalis or intestinalis (Parasite)</strong></td>
<td>Contaminated water and raw or uncooked meats of infected animals.</td>
<td>• Areas with poor water sanitation can harbor the parasite.</td>
</tr>
<tr>
<td><strong>Cryptosporidium parvum (Parasite)</strong></td>
<td>Water and food contaminated with feces from infected individuals or animals.</td>
<td>• Many herd animals can harbor the parasite in their intestines and transfer it through feces. • Avoid using water for food production or drinking from unknown sources or those used by livestock or wild animals. • Prevent sick individuals from working with or around food.</td>
</tr>
<tr>
<td><strong>Various species of mold that produce mycotoxin</strong></td>
<td>Molds and their spores can be found naturally in the air, soil, and other environmental sources. Foods can be sources of mold growth and toxin production if spores are present on the food or food storage areas.</td>
<td>• Many grain crops can become sources of mold growth which produce mycotoxin. • Growers should be trained to identify and remove moldy crops and use harvesting and storage practices which prevent mold growth. • Avoid consuming foods with visible mold growth or stored in areas with visible mold growth.</td>
</tr>
</tbody>
</table>
Food Contact Surfaces

In addition to focusing on the parameters of the food, the surfaces in which those foods will come into contact are also especially important in controlling food safety hazards. Any surface which can come into contact with a food item is referred to as a food contact surface. During processing or preparation of food, special care must be taken to ensure these surfaces are properly cleaned and sanitized before and after use, to ensure they do not become sources of contamination.

Food contact surfaces can include:

- Cutting boards
- Utensils (knives, spatulas, tongs, spoons, etc.)
- Preparation surfaces (tables, counters, trays, etc.)
- Storage surfaces (refrigerator shelves, storage bins, storage bags, etc.)
- Mechanical slicing equipment (i.e. deli slicers)
- Worker’s hands

Regulations

The regulation of food in the United States is a complex process, consisting of many local, state, and federal agencies working in tandem to ensure a safe food supply. It is important to understand the responsibilities and roles of these regulatory agencies, and how they impact those involved with producing and selling food at farmers’ markets.

In general, many of the vendors at farmers’ markets will fall under state and local regulatory authority. However, there are certain instances when federal regulations, either through FDA or USDA, may be applicable.

United States Department of Agriculture (USDA)

In the U.S., all meat, poultry, and egg product processing is regulated by the USDA. Within the USDA, the Food Safety Inspection Service (FSIS) is the agency responsible for carrying out inspection and regulatory activities. All of the current regulations for meat, poultry, and egg products originate from three laws passed by congress. Regulations for the slaughter and processing of meat in the U.S. are found in Title 9 “Animal and Animal Products” in the Code of Federal Regulations (CFR). For more information or assistance with meat and poultry inspection, contact your applicable USDA-FSIS district field office.

Meat and Farmers’ Markets – Livestock farmers seeking to sell meat at farmers’ markets must have livestock slaughtered at a federally-inspected slaughter facility. Meat originating from a federally-inspected facility must bear the USDA mark of inspection and establishment number. Based on current regulations, meat retailers who meet the federal requirements of a retail exempt meat processor can perform further processing on inspected meat (cut up, trim, slice, grind, freeze, cooked, cured, smoked, rendered, refined, or other processing), and sell those products to household consumers at farmers’ markets. Contact your applicable USDA-FSIS district field office or state and/or local sanitarian for more information on processing meat for sale at farmers’ markets.
**Poultry and Farmers’ Markets** – Poultry farmers and processors seeking to sell poultry at farmers’ markets must either have poultry slaughtered at a federally-inspected facility, or perform those operations under a federally approved exemption status. Poultry originating from a federally inspected facility must bear the USDA mark of inspection and establishment number; however exempt processors will not bear the USDA mark of inspection.

Based on current regulations, poultry retailers who meet the federal requirements of a retail exempt poultry processor, may perform further processing on federally inspected poultry (cut up, trim, slice, grind, freeze, cooked, cured, smoked, rendered, refined, or other processing), and sell those products to consumers at farmers’ markets. If poultry is slaughtered and processed under a separate exemption status, other than personal use or custom slaughter/processing operations, further processing also may be performed on those products and sold into commerce or direct to consumer. Contact your state and/or local sanitarian for more information on processing poultry for sale at farmers’ markets.

**The Food and Drug Administration (FDA)**

The FDA is the federal agency responsible for the regulation and inspection of most of the U.S. food processors outside of meat, poultry, and non-shell egg products. The FDA also has oversight of numerous other areas, such as shell eggs, animal feed, cosmetics, dietary supplements, drugs, medical devices, tobacco products, vaccines and biologics, and radiation-emitting products.

FDA also prepares the Food Code, a list of best practices that is incorporated either in full or in part, into state and local regulations.

**FDA and Farmers’ Markets** – Many farmers or small producer who process food and sell food products (except meat, poultry, or egg products) at farmers’ markets, should understand whether they need to register their facilities with the FDA. Establishments exempt from the requirement for registration includes farms, retail food establishments, restaurants, and nonprofit food facilities. The term “retail food establishment” is an operation that has its primary function as the sale of food products directly to consumers and includes:

- The sale of such food products or food directly to consumers by such establishment at a roadside stand or farmers’ market where such stand or market is located other than where the food was manufactured or processed.
- The sale and distribution of such food through a community-supported agriculture program.
- The sale and distribution of such food at any other such direct sales platform, as determined by FDA.

It is important to work with a local and/or state sanitarian to determine the requirements to register with the FDA. Vendors also can contact their local FDA district office to determine registration status.

**The FDA Food Code**

The FDA Food Code was developed in 1993 to assist all jurisdictions of government, by providing a scientifically sound and legal basis for regulating food safety in the U.S. food retail industry. Model codes, such as the FDA Food Code, are not federal law or regulation, but are scientifically-validated guidelines produced by federal scientists and regulators. It is the decision of each local, state, and other
jurisdictions to either adopt the FDA Food Code in part, in whole, or develop their own retail food safety regulatory standards.

To date, all fifty states in the U.S. have adopted the FDA Food Code in some manner, and have incorporated those guidelines into their own food retail codes and regulations. The FDA Food Code is divided into chapters, covering areas such as retail food related terms and definitions, retail management and personnel, procedures for handling specific types of food, use of equipment, utensils, and linens in the retail setting, facility maintenance and sanitation, and compliance and enforcement guidelines.

In general, the FDA Food Code is a useful reference guide for any individual who processes or sells food in the retail setting, and in most states, is the basis for retail food safety inspections and regulations. Much of what is presented in this guide is based upon the Food Code.

State and Local Regulatory Authorities

In the U.S., state and local government agencies have the authority over retail food establishments, creating regulations, and inspecting operations. Many farmers’ market vendors are considered this type of food retail operation. Due to this distinction, many of the current policies and regulations regarding the sale of foods at farmers’ markets are based on the rules and guidelines of the FDA Food Code and the oversight, which falls to state and/or local inspectors.

State and local agencies also can carry out food safety-related federal inspections on behalf of the FDA and USDA. In some cases, local and state municipalities also may implement additional regulations, in addition to the federal standards.

It is also important to understand that many states have enacted different regulations for specific food commodities, and there may be additional requirements to comply with in each state. Local municipalities also may enact ordinances or local laws which may prohibit or allow certain food processing or sales. Determining the state and local regulations is an important first step before beginning the production and sale of food at farmers’ markets.

Farmers’ Market Specific Regulation and Inspection

Due to the popularity of farmers’ markets in the U.S., many states such as Pennsylvania, have passed laws and produced food safety regulations specific for farmers’ markets. In these instances, the local and/or state sanitarians may require farmers’ market vendors to be licensed and to follow food safety standards similar to those required by a retail food establishment.

Retail Food Safety Certifications

Based on the recommendations of the FDA Food Code, most states in the U.S. will require food retail operations to have at least one person who holds a Food Safety Manager Certification, using state-specific training programs from nationally-accredited testing programs.

Farmers’ market vendors or small food producers may be required to be certified in one of these programs if high-risk food items are produced, or if those establishments are considered a retail food
operation by the applicable state. Check with a local and/or state sanitarian to determine the requirements for retail food safety certifications.

Currently, four nationally-recognized programs are available which are accredited by the American National Standards Institute (ANSI).

- 360training.com, Inc. (Learn2Serve® Food Protection Manager Certification Program)
- National Registry of Food Safety Professionals (Food Protection Manager Certification Program)
- National Restaurant Association (ServSafe® Food Protection Manager Certification Program)
- Prometric Inc. (Food Protection Manager Certification Program).

Many local municipalities, state Cooperative Extension systems, and private academic institutions also may offer these courses free or for a nominal fee. Check with these organizations or explore other training locations from the specific program websites.
Chapter 2: Food Safety Concepts – Controlling Risk from Farm to Fork

This chapter presents the four key concepts for keeping food safe:

- Controlling time and temperature.
- Preventing cross contamination
- Cleaning and sanitizing food contact surfaces
- Practicing proper personal hygiene

Controlling Time and Temperature

Temperature control – Temperature control is important for controlling microbial pathogens on TCS foods. Thermal treatments, such as cooking or pasteurization, are used for eliminating pathogens, as well as spoilage organisms. The temperature range that best supports the growth of bacteria is from 41°F to 135°F, known as the TDZ. Keeping foods out of the TDZ prevents organisms from growing in food.

Cooking foods – Cooking is the primary way to destroy microbial pathogens that may be present on or in foods. Raw meats and poultry must be cooked until they reach a specific temperature in order to kill the foodborne pathogens that are likely to be present, such as *Salmonella* and *Campylobacter*.

Chilling foods – After TCS foods are cooked, they must be cooled quickly to keep those foods from staying in the TDZ too long. Spore-forming pathogens, such as *Clostridium perfringens* can survive the cooking process, and grow on or in food if it is kept in the TDZ too long.

When storing or holding TCS food, it is important that those TCS foods are stored outside of the TDZ. Foods that are going to be held hot and served hot must be stored or held at temperatures above 135°F. Foods that are going to be held and serve cold must be stored or held at a temperature of 41°F or lower. During the handling, preparation, and serving of TCS foods, it is important that the time those foods spend in the TDZ is minimized.

Thermometers – To ensure proper time-temperature control, temperatures must be monitored with the use of thermometers. There are two primary types of thermometers used in food processing – bimetallic and digital, which include thermocouples and thermistors. Choosing the right type of thermometer probe depends on what it will be used for. Penetration probes are more rugged for sticking into meat. Emersion probes are longer probes that can be used for measuring the temperature of a vat of soup. It is important that when buying a thermometer probe that its application be considered. Note that glass thermometers are not normally used in food processing, with very few exceptions, such as candy production. If a glass thermometer will be used, it must have a sheath to protect against cracking and breaking into food.

It is important that thermometers are accurate to (+/- 2 °F). For bimetallic thermometers, regular calibration is critical. Although digital thermometers are not calibrated normally, it is important to check that the internal calibration is correct. The ice point calibration or a boiling point calibration methods are two easy ways to check the accuracy of the thermometer.

* Calibration methods are described in Appendix 2.*
Recording temperatures during food preparation and processing is a good practice because it verifies that the temperature monitoring activity is occurring, and this record can be used for later review.

Specific times and temperatures for cooking, cooling and holding will be covered in chapter 5.

Preventing Cross Contamination

Cross contamination – Cross contamination is the transfer of hazards (biological, chemical, physical) from a contaminated source to a food or food contact surface. It can happen anywhere in the flow of food production or preparation, but is of special concern when working with RTE and TCS foods.

While microbial pathogens are a primary concern when discussing cross contamination, chemical hazards or contaminants also can be transferred. Allergens are a special concern if they are transferred from a food or food contact surface to another food which does not declare allergens on the food label. The term used for the unwanted transfer of allergens is called cross contact.

The following are key ways to prevent cross contamination:

- Separate raw and RTE foods – keeping raw foods, especially raw meat and poultry, separate from RTE foods decreases the opportunities for cross contamination. This approach can include storage of raw meat in a separate cooler from RTE items, or working with raw foods at a different time than RTE foods.
- Using separate equipment for raw and RTE foods – An example of this approach would be using color-coded cutting boards designated for either raw foods, such as meat, and RTE foods, such as bread or sliced produce.
- Using prepared food and ingredients – The use of prepared ingredients instead of raw foods, particularly meats and poultry, can help minimize the risk of cross contamination. For example, instead of using raw meat on a pizza, use cooked meat.
- Cleaning and sanitizing – Cleaning and sanitizing is the most important way to prevent cross contamination and cross contact of allergens. Surfaces that become contaminated should be cleaned and sanitized as needed. It is important to clean and sanitize food contact surfaces after each use and before working with RTE foods.

Cleaning and Sanitizing Food Contact Surfaces

Sanitation has two primarily components – cleaning and sanitizing. Cleaning is the removal of food debris from the surface while sanitizing is the process of reducing harmful microbial pathogens to safe levels. While many areas in the facility must be cleaned on a regular basis, it is especially important that food contact surfaces are cleaned and sanitized properly.

The general procedure for cleaning and sanitizing is as follows:

- Remove large debris by scrapping, soaking, and/or rinsing with potable water.
- Clean with a food grade soap or chemical cleaner.
- Rinse with potable water to remove soap or cleaner.
- Sanitize with an approved sanitizer.
- Air dry.
Food contact surfaces must be properly cleaned and sanitized:

- After they are used.
- Before beginning a new task.
- After a prolonged interruption of work.
- Any time that surface may have become contaminated.
- After a 4 hour period of processing or preparation (unless processing in a refrigerated area).

Soaps and Cleaners – There are a number of different soaps and cleaners that can be used during cleaning. It is important to use the right soap or cleaner for the right application (grease, dirt, oils, etc.). It is also important to make sure the cleaner is EPA or FDA approved for use on food contact surfaces. Contact your state and/or local sanitarian for more information on the use of soaps and cleaners for food processing and preparation.

Rinsing – A thorough rinse using potable water follows the cleaning step and this step removes all of the detergent. Any residual detergent on the surface being washed can inactivate the sanitizer, so it is important to rinse thoroughly.

Sanitizers – After rinsing, the items must be sanitized. There are a number of sanitizers that can be used which are EPA or FDA approved for use on food contact surfaces and in food production areas. Two types that are used often include chlorine-based sanitizers and quaternary ammonium compounds (i.e. Quat). Hot water (171°F or greater) also can be used to sanitize in place of a chemical sanitizer. Regardless of the type used, it is important that you follow the manufacturer’s directions, ensuring that the sanitizer is used at the recommended temperature, concentration, and contact time. To verify sanitizer concentrations, a wide variety of dip strips are available to measure the level or concentration. Contact your state and/or local sanitarian for more information on the use and testing of sanitizers for food processing and preparation.

Air Dry – It is best to allow surfaces to air dry. Wiping them down with a cloth may re-contaminate the surface.

Wiping cloths – Wiping cloths used for service counters and tables must be stored in a chemical sanitizer and laundered daily. It is important that if cloths are being used for cleaning surfaces with raw meat, poultry or seafood, that they are kept separate from those cloths used for service areas.

Three-compartment sinks – When using a three compartment sink to clean food contact surfaces or utensils, the sink should be cleaned beforehand.

Practicing Proper Personal Hygiene

People working with food can be a source of contamination. In some cases, they can have an illness that they pass from the food they have handled to the consumer, who eats that food. In other cases, they can cross-contaminate food through dirty hands, clothing, or bodily fluids (i.e. saliva). Jewelry that is worn or objects in pockets can become physical hazards when they fall into food accidentally.

Personal Hygiene Program – A good personal hygiene program is essential for preventing contamination from personnel. The facility should have a written program and all personnel should be trained before they begin work and then on an ongoing basis, at least yearly.
Handwashing – Proper handwashing is one of the most important personal practices in preventing contamination of food. Hands should be washed in a designated handwashing sink.

To properly wash hands:

- Rinse hands under warm running water.
- Apply hand soap or other approved hand cleaner.
- Scrub hands for 10 to 15 seconds, paying attention to cleaning between fingers and under fingernails.
- Rinse hands.
- Dry with a single use paper towel or hand dryer, never use a shared cloth towel.

It is important to wash hands before working with food, as well as after any instance when they may have become contaminated, including:

- Use of the restroom.
- After touching body parts, including hair and face.
- After coughing, sneezing, and/or eating.
- Handling money.
- Touching raw foods, especially raw meats, poultry, or seafood.
- Touching animals.
- Touching any contaminated surface.
- After 4 hours of continuous use.

Hand sanitizers – Hand sanitizers do not take the place of handwashing, but can be used in conjunction with proper handwashing. If using hand sanitizers, they must be approved for use in food applications. Contact your state and/or local sanitarian for more information on the use of hand sanitizers for food processing and preparation.

Glove Usage – Gloves must be worn any time when handling RTE foods. This approach does not include raw unwashed fruits and vegetables, nor do gloves need to be worn when washing fruits and vegetables.

Gloves must be single use and be changed any time they become dirty, when changing tasks, or when they become ripped or torn. Hands must be washed before putting on gloves, which must be put on so that you don't contaminate them, which can occur when rolling them on.

Personal Cleanliness – Employees working with food should wear clean clothing and bathe regularly. Hair covering should be worn when working with food so hair does not have an opportunity to fall into foods. While hairnets are ideal, hats or visors which restrain hair also can be used. In addition, false fingernails, fingernail polish, hairclips, and hairpins should not be worn when handling or preparing food.

Personal Items – Employees must not have personal items that can become physical hazards, including pens, hair restraints or jewelry. The only jewelry that is allowed by the FDA Food Code is a plain wedding band.
Health Considerations – Employees who have symptoms of vomiting or diarrhea must be prevented from working with food. This means that they should stay home and wait for 24 hours after the symptoms have cleared before returning to work.

Jaundice is another symptom, which is characterized by the yellowing of the skin and eyes, and requires an employee with those symptoms to stay away from the operation. In addition, it is a requirement that the local or state public health department is notified if employees show signs of jaundice. Jaundice may be an indication of Hepatitis A, a highly contagious disease that can be spread through food.

If an employee has been diagnosed by a physician with any of the following infections, it is also the employer’s responsibility to notify the local or state public health department.

Employees with the following illnesses cannot return to work until they have been cleared by a medical practitioner:

- *Salmonella* Typhi
- *Salmonella* species other than Typhi
- *Escherichia coli* (STEC)
- *Shigella*
- Hepatitis A
- Norovirus

This chapter presents key areas for maintaining clean and safe facilities to minimize risk in food processing and preparation facilities:

- Facility grounds and exterior
- Facility interior floors and walls
- Storage areas
- Food processing equipment
- Washing equipment
- Water and plumbing
- Trash disposal

The facilities (structure, walls, floors, equipment, utilities) at a food preparation facility can vary and great impact the safety of food products produced in those areas. Overcoming facility limitations doesn’t have to be difficult or expensive, but considerations should be made to ensure high levels of cleanliness are maintained when preparing or processing foods.

Facility Grounds and Exterior

Outdoor areas should be maintained to minimize dust and prevent standing water. Asphalt or concrete are ideal choices. Weeds and other vegetation should be minimized or at least maintained to better control pests.

Exterior walls – Walls should be weather-resistant and free of holes or cracks that could allow entry of contaminants or pests. Exterior openings to facilities should have doors and windows which are tight fitting and kept closed. If ventilation is required, such as when opening a window for example, screen mesh coverings (16 gauge mesh) should be in place.

Interior – Indoor facilities should have surfaces that are easily cleanable. This means that surfaces are smooth and free of cracks and crevices. Surfaces located in areas that may come in contact with moisture should be nonabsorbent.

Interior floors and walls – Floors should be free of barriers that prevent proper cleaning, such as horizontal service lines or pipes. Porous walls, such as masonry block, should be coated if they are in food preparation areas. Floor/wall junctions should be coved or sealed to prevent absorption of water and make cleaning easier. Carpets are not allowed in food preparation areas.

Drains – Drains should be in place where wash-down procedures are used and the floor should be sloped so that they adequately drain.

Light bulbs – Light bulbs should be shielded, covered, or coated to protect against breakage in areas where food is exposed.

HVAC – Heating, ventilation, and air conditioning systems should be designed and installed so that intake and exhaust vents cannot lead to contamination from dust and duct build-up. The systems should be capable of removing smoke, fumes, and steam.
Insect control devices – Insect or pest control devices should not be used or stored over food preparation areas and should be designed and installed so that insect or insect parts cannot fall onto exposed food or food contact surfaces.

Eating and Drinking Areas – An area should be designated for employees to eat and drink. These areas should be located away from food preparation areas and utensil cleaning areas. Animals must be excluded from these areas in addition to any food processing areas.

Temporary Facilities

In temporary facilities, asphalt, dirt or gravel can be used if it is covered to control dust and prevent mud and standing water. The walls of a temporary operation should protect the interior from the weather and wind that can carry dust and debris. Studs, joists and rafters may be exposed in temporary facilities, but not in permanent facilities.

Storage Areas

Food and ingredient storage areas should be kept dry and free of debris. Food items and food utensils should be stored at least 6 inches off the floor to allow for easy cleaning and inspection for pests.

Food or ingredients should never be stored in locker rooms, toilet rooms, garbage rooms, in mechanical rooms, or under unshielded sewer lines, leaking water lines, open stairwells, or any other things that can cause contamination to occur.

Cleaning chemicals and maintenance chemicals should be stored in a separate location to prevent the potential for chemical contamination.

Food Processing Equipment

Food contact surfaces of equipment should be safe, durable, corrosion-resistant, and non-absorbent. They should be easy to clean, free of cracks, chips, sharp angles, and rough welds or joints.

Equipment should be placed to facilitate cleaning around and under that equipment. Floor-mounted equipment must either have 6 inches of clearance from the floor or be sealed directly to the floor. Tabletop equipment must have 4 inches of clearance or sealed directly to the table.

Food equipment should be certified by an American National Standards Institute (ANSI) or accredited certification program such as the National Sanitation Foundation (NSF).

Stainless steel is the preferred choice of materials to be used for equipment and food processing surfaces.

The following are some common materials which may have limitations or restrictions for use in food processing and preparation:

- **Cast iron** – not to be used, with the exception of cooking surfaces that have been properly prepared (seasoned).
- **Lead** – not be used, including pewter, soldered items, and items that are painted with lead-based paint.
- **Cooper and copper alloys** – not to be used with food that has a pH less than 6.0.
- **Galvanized metal** – not to be used on food contact surfaces.
- **Sponges** – not to be used on cleaned and sanitized food contact surfaces.
- **Wood** – not to be used on food contact surfaces with the following exceptions: cutting boards, cutting blocks, rolling pins, salad bowls, chopsticks, wood paddles used in confectionary operations, racks used for holding whole uncut raw fruit and vegetables, and nuts-in-shell.

**Cutting boards** – Surfaces such as cutting blocks and boards that become scratched or scored to a point where cleaning becomes difficult must be resurfaced or discarded.

**Ventilation hoods** – Should be maintained in a way that there is no build-up of grease or condensation.

**Temperature measuring devices** – Devices used for measuring the temperature of food should be accurate to (+/-2°F) and be able to be manually calibrated. They should be made of a sturdy material that is not subject to corrosion. Glass thermometers should not be used. For air temperature and cooler temperatures, thermometers must be accurate to (+/-3°F)

When used to measure refrigerated storage units, the temperature measuring device should be located in the warmest spot of the cooler.

**Bearings and gear boxes** – Equipment containing bearings and gears that require lubricants should be constructed so that lubricant cannot leak, drip, or be forced onto food or food contact surfaces.

**Washing Equipment**

**Automated washing equipment** – Mechanical or automated washing equipment must be operated according to the manufacturer’s instructions, ensuring that operating parameters are being met, including temperature, pressure, and chemical concentration. Typical dish washers made for home use will not have the option of setting those parameters.

**Handwashing sinks** – Each handwashing station should have soap, potable water, handwashing signage, a garbage disposal receptacle, and a way to dry hands (e.g. single use paper towels or hand drying devices that use warm air or high velocity air. Hot water used in the handwashing station must be at least 100°F.

**Warewashing sink** – For manual warewashing, a three-compartment sink is normally required. If the warewashing sink is used to wash wiping cloths or produce, or to thaw food, the sink must be cleaned before use, and throughout the day at a frequency sufficient to prevent contamination. A warewashing sink is not to be used for handwashing.

**Service sink** – A service sink or floor drain system should be available for cleaning tools and disposal of mop water and other liquid waste.

**Water Used for Food Processing or Preparation**

**Potability** – Water used in food applications, whether for drinking, washing raw produce, blending, or washing equipment, must be potable and deemed safe for use as drinking water by a local, state, or federal water regulatory authority. Water can be sourced from the local municipality or from a local well if that well is tested, as required for potability, and those testing records are kept on file. Typically, testing is required at least once a year. However, check with your local water regulatory authority for more information. In the absence of piped water from an approved source, potable water can be delivered by a water tanker or water containers.
**Plumbing** – Plumbing systems, including holding or surge tanks and piping, must be made from approved materials and maintained in a way that prevents contamination. They should have appropriate covers to prevent potential contamination.

For mobile units, water tanks and hoses must be made of approved materials and the water should be protected from contamination, with special attention to the outlet and inlet port as well as the vent.

**Back flow** – Approved backflow or back-siphonage prevention devices should be installed in all locations where there is a risk of a cross connection between the potable water source and potentially contaminated water (i.e. a mop bucket full of water or an outside puddle of water).

**Pressurized water** – Compressed air systems used for pressuring the water system should have a filter that prevents oil or oil vapor from contaminating the water.

**Trash Disposal**

**Indoor trash containers** – These containers should be leak-proof, cleanable, and covered when not in use. Trash receptacles should be cleaned regularly.

**Outdoor trash containers** – These containers should be located on a concrete or asphalt surface. The covers should be kept closed and the drain plug should be closed.

**Recyclables Containers** – Recyclables should be collected in an area that is located away from food preparation and food storage areas. They should be stored so that they do not attract or harbor pests.
CH 4: Sourcing and Purchasing – The Ingredients to Keep Foods Safe

This chapter presents key areas for sourcing and purchasing ingredients and goods for food processing and preparation.

- Approved suppliers
- GAPs, GMPs, and HACCP
- Inspection of incoming goods
- Supplier recalls
- Selling other farmer’s goods

Approved Suppliers

Obtaining ingredients and other food products from approved, licensed, inspected, and respectable suppliers is a key component of managing food safety risks in the preparation or processing of your food products.

Grocery Stores – For many farmers and small food processors, grocery stores or other food retail outlets may be a source for purchasing food ingredients. Technically, food products sold in a retail grocery store should come from suppliers who have been inspected and gone through an approval process. However, for less familiar brands or unbranded products, such as commodity items, some further investigation may be needed to determine the source of the product and the qualifications of the supplier. This step may require you to contact the supplier directly.

Ingredient Suppliers – Farmers and food processors may choose to purchase ingredients or packaging materials directly from a producer (i.e. farmer), processor, or broker.

Before purchasing ingredients from a new supplier the following information should be collected:

- Qualifications of the supplier.
- Inspection reports and licenses.
- Supplier contact information.
- Product labeling, coding, and tracking details.
- Notification process for supplier recalls.

Good Agricultural Practices – When purchasing produce directly from farmers, it is important to know that the farmer is using Good Agricultural Practices (GAPs). GAPs are practices, measures, and standards which farmers can follow to reduce food safety risks throughout planting, growing, harvesting, and post-harvest operations. GAPs are recognized and supported by the USDA and FDA. Farmers who have established a GAPs program can voluntarily request to be audited by state, federal, or certified third party auditors. These audits serve as a verification that the farmer is following the prescribed GAPs standards and practices.
Use the following questions to help discuss GAPs with a farmer and potential supplier:

- Does the farmer follow GAPs, and do they have written procedures and plans which you can view, including use of manure as a fertilizer, irrigation, pesticide use, farm and wild animal separation, and post-harvest procedures for packing, washing, storage, and shipment?

- If they do not follow GAPs, do they adhere to any other similar food safety practices during field and post-harvest operations?

- Has the farm passed a voluntary GAP audit, and can you view the results?

**Good Manufacturing Practices** – Good Manufacturing Practices (GMPs) are a set of rules, guidelines, and practices to follow in the production of food to minimize food safety risks and maintain quality. In general, GMPs cover areas such as personal hygiene, training, allergen control, building and facilities, equipment and utensils, production and processing controls, pathogen control, record keeping, and sanitation operations.

GMPs should be incorporated as part of the policies and procedures used by raw material suppliers to control the safety of the product. To assess or verify that these systems are in place, the supplying facility should be able to provide an inspection report that was completed by a regulatory inspection agency or a third party inspection.

In addition to GMP’s, most FDA- or USDA-inspected food or meat, poultry, and egg processing facilities will utilize risk based systems, such as HACCP, to control and manage risks specific to the food manufacturing process.

**Hazard Analysis and Critical Control Points (HACCP)** – HACCP is a risk-based management system primarily used in the meat and poultry industry to reduce and control the biological, chemical, and physical hazards associated with specific food production processes. In the U.S., the use of a HACCP-based system is required in order to produce meat, poultry, and egg products under USDA inspection. Other FDA-inspected food products, such as juice and certain seafood products also are required to utilize HACCP-based systems to control hazards throughout the processing of the food product.

Who is required to have a HACCP plan?

All USDA-inspected food processors (i.e. meat, poultry, and egg products) are required to develop and implement a HACCP plan to control food safety risks during processing. These regulations are described in Title 9 Part 417 of the Code of Federal Regulations (CFR). With the enactment of the Food Safety Modernization Act, FDA-regulated food facilities will be required to utilize a HACCP-based system as part of their food safety plan. Prior to 2015, only facilities producing seafood and juice products were required to have HACCP systems in place. However, due to customer agreements, HACCP-based systems were utilized by many processing companies, even though regulatory requirements were not in place. With smaller companies, including food service companies, that do not fall under federal jurisdiction, the FDA Food Code establishes required HACCP systems for specific food production processes, including ROP packaging, smoking and curing, acidification, and sprouting beans or seeds.
Inspection of Incoming Goods

It is important that incoming raw goods are first inspected prior to receipt, whether purchased at a retail outlet, through a broker, or direct from a farmer or processor.

Have designated personnel complete an inspection of incoming goods, preferably in a non-production area. Hold incoming shipments in that area until you have determined they are safe and suitable for storage and further processing.

Use the following checklist to help inspect newly purchased or incoming goods and supplies:

- Delivery vehicle status – is the inside of the delivery vehicle clean and free of materials that may have contaminated the product?

- Correct material – verify that the correct items purchased have been received. For food items, ensure that the ingredient statements are correct, especially allergen containing ingredients.

- Package code and expiration dating – package codes should be present and the product should not be expired.

- Packaging integrity – the packaging is intact with no signs of tears, holes, or tampering, which could compromise the integrity of the product.

- Product integrity – Product should not be damaged or exhibit any issues including off-odors, discoloration, or mold.

- Signs of pests – Product should be free from insects or rodents. Look for indicators of pest infestation on the packaging, pallets, or other shipping materials, including droppings, urine smell, bite marks, dead insects, insect parts, fur or feathers, or other signs of pests.

For TCS items requiring temperature control, check the internal temperature of the product, as well as the delivery vehicle or display case temperature.

- Fresh foods should be received below 41°F while frozen foods should have remained frozen (below 32°F) with no signs of thaw.

To verify the temperature of the shipment, randomly choose several items and insert the thermometer into the thickest portion of the product. Packaged product can be opened or for reduced oxygen packaging (ROP) packaged material, wrap the package around the stem of the thermometer.

Do not accept the shipment if the temperature is not in the correct range and contact the supplier immediately.

Once received, store any temperature sensitive food products immediately. For store purchases, store refrigerated and frozen product in a cooler with ice or other proper storage device prior to transport back to your facility.
This chapter presents key areas for product handling and preparation.

- Food preparation and processing
- Washing
- Mixing, blending, and grinding
- Cooking, chilling, and thawing
- Packaging
- Labeling
- Transportation
- Point-of-sale preparation

Food preparation and processing

While raw agricultural commodities are a primary focus at many farmers’ markets, prepared or processed foods are becoming increasingly popular. The processing of food can include activities as simple as washing, to more complicated procedures involving heating and packaging. While many of these processes are completed at a dedicated facility (because of equipment or utility requirements), some may occur at the farmers’ market.

Food preparation or processing, whether occurring in a packing shed, in a processing plant, or at the farmers’ market, must be performed under sanitary conditions and any food safety hazards must be controlled. It is important to remember that the lack of a permanent food preparation facility does not exempt a vendor from following the same practices that would be required in a retail-type food facility.

In this section, a number of different processing activities will be reviewed, while also discussing specific regulatory requirements that may apply to those processes. Whether that preparation includes washing, mixing, cooking, chilling, or some other process, careful attention must be taken to ensure that activity is performed in a sanitary manner, and does not introduce contamination. If specific cooking and cooling procedures are required, then those procedures must be strictly followed, monitored, and verified. It is also important to understand that as vendors move into performing more complex food preparation or processing, certain regulatory restrictions may apply, and additional licensing may be required. Contact your local and/or state sanitarian for more information on specific regulatory restrictions that may apply.

Washing

Washing systems are important for cleaning food items for immediate sale (i.e. produce), as well as if they will be used for further processing. The water used in wash systems must be potable. Water reuse systems can be used, however, ensure that the last rinse is a “clean water” rinse. Sanitizers also can be added to wash water, provided they are approved for food use and approved concentrations are used.

Wash systems must be maintained so that they do not become a source of contamination. Flume lines, recirculating pumps, reserve tanks, brushes, and sprays must be cleaned regularly. It is important to use materials in your wash systems that are cleanable.

Chemical additives – If chemicals or other additives will be mixed with wash or rinse water as a sanitizing agent or to assist in the peeling of fruits and vegetables, those chemicals must be approved for use. Those approved chemicals also must be used in accordance with the manufacturer’s instructions.
Washing of produce – According to the FDA Food Code, the washing of fresh fruits and vegetables is considered a processing step, and as such, would require those food items to be handled as RTE foods after being washed. Unwashed fruits and vegetables would not be viewed in the same manner, since it is assumed that the consumer would perform the tasks of washing, peeling, hulling, or shelling before consuming the product. A brief rinse of produce to remove dirt and debris following harvest would not be considered a washing step.

Whole or cut raw fruits or vegetables can be stored or displayed when immersed in ice or water, however check with your local or state sanitarian to determine the requirements for this process.

Raw fruits and vegetables – Any raw fruit or vegetable must be washed before being cut, combined with other ingredients, cooked, served, or offered for human consumption in a RTE form.

Washing during processing and preparation – If washing will be performed as part of the preparation or processing of a food item, ensure that the washing area is separated from other processing areas, such as the final product storage or packing areas, to avoid cross-contamination.

Washing whole poultry and meat products – It is not necessary or recommended to wash finished whole meat, poultry, or seafood products with water, outside of normal processing steps, such as the application of an antimicrobial rinse or dip (i.e. lactic acid) during poultry slaughter. The washing of raw, finished animal products can spread harmful bacteria into the processing environment.

Sanitizing wash or rinse for poultry – Poultry (chicken, turkey, other fowl) processors who slaughter or process whole poultry can increase the safety of their products through the use of an antimicrobial rinse or dip. This processing step can be performed prior to packaging to reduce the levels of harmful bacteria still present on the carcass or separated parts. Many organic and natural sanitizers are commercially available, including lactic acid, peracetic acid (PAA), and hydrogen peroxide. Other commonly-used sanitizers are chlorinated water, acidified sodium chlorite (ASC), and bromine. Application of these sanitizers can be as simple as dipping the carcass into the solution or using a hand-held pump and spray nozzle, available at any local hardware store.

In the U.S., the USDA regulates the types of sanitizers and concentrations which can be used during poultry processing. This information is described in detail in the FSIS Directive 7120.1 “Safe and Suitable Ingredients Used in the Production of Meat, Poultry, and Egg Products.” For more information on the use of sanitizers during poultry processing, contact your county Extension office or speak with your local and/or state sanitarian.

Mixing, Blending and Grinding

Mixers, blenders, and grinders are used to prepare a uniform mixture of different ingredients and/or change the size or shape of a product. This type of equipment can become the source of biological or chemical hazards if not properly cleaned, and can be the source of physical hazards if not properly maintained or used.

Mixing, blending and grinding: physical hazards – Equipment must be maintained, undergo regular inspection, and made of the proper materials to prevent hazards from being incorporated into foods. Equipment made from improper materials can chip or splinter during use. For example, wood spatulas can splinter into foods, so wood is discouraged from use, except in specific applications. Metal shavings can be generated in a grinder if grinder blades and plates are not properly installed or have excessive ware. Procedures should also be in place to prevent materials from falling into food. For example, plastic buckets and plastic twist ties can be shredded in a mixer if they accidently fall in during the addition of an ingredient.
Mixing, blending and grinding: chemical hazards – Equipment should be made of a material that will not react with ingredients. If working with acidic foods (below pH 7; i.e. tomato sauce, lemon juice, vinegar), the equipment must be made of a material that will not leach poisonous metals, such as lead, zinc, or copper. Equipment must also be checked to ensure that residual sanitation chemicals are not present before operation and that lubricant from the equipment does not make its way into the food during operation.

Allergens – Residual allergens left on the equipment from a previous batch can transfer to a food product that has a label where that allergen is not declared. Proper cleaning and sanitizing is the most effective way to remove allergens, but verification checks, including visual observation, may be needed to ensure that no materials are present after cleaning. Back-to-back production runs must be managed so that allergen-containing food products are produced after foods containing no allergens and not vise-versa.

Cooking – Any cooking that will be performed during the processing of a food product or at the farmers’ market, as part of the preparation of a RTE food, must be performed in accordance with the requirements of the FDA Food Code (3-401.11) or applicable USDA, FDA, or state regulations. It is important to determine the specific cooking requirements for the type of food products you may be preparing or processing. Vendors who wish to deviate from the established temperature guidelines should contact their local regulatory authority before they begin.

Specific final cooking temperatures for different food products have been established, based on the various kinds of food safety risks associated with each food (See Table 5.1.). The doneness of cooked food should never be evaluated using color change, touch, or taste. Taking the temperature of a cooked food is the only scientifically-validated way to determine if the food is safe to eat.

In cases where the consumer is expected to cook the product, the proper approach must be communicated to the customer. This information can be conveyed through labeling, as well as having knowledgeable sales persons.

Table 5.1 Consumer Cooking Guidelines (Safe Minimum Cooking Temperatures)

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Food</th>
<th>Temperature (°F)</th>
<th>Rest Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Meat &amp; Meat Mixtures</td>
<td>Beef, pork, veal, lamb</td>
<td>155</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Turkey, chicken</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td>Fresh Beef, Veal, Lamb</td>
<td>Steaks, roasts, chops</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Poultry</td>
<td>Chicken &amp; turkey, whole</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Poultry breasts, roasts</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Poultry thighs, legs, wings</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Duck &amp; goose</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Stuffing (cooked alone or in bird)</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td>Pork and Ham</td>
<td>Fresh pork</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>Fresh ham (raw)</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>Precooked ham (to reheat)</td>
<td>140</td>
<td>None</td>
</tr>
<tr>
<td>Eggs &amp; Egg Dishes</td>
<td>Eggs</td>
<td>Cook until yolk and white are firm.</td>
<td>None</td>
</tr>
</tbody>
</table>

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<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Egg dishes</strong></td>
<td>155</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>**Leftovers &amp;</td>
<td>Leftovers</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td>Casseroles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fin Fish</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>145 or cook until flesh is opaque and separates easily with a fork.</td>
<td>None</td>
</tr>
<tr>
<td><strong>Shrimp, lobster, and crabs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cook until flesh is pearly and opaque.</td>
<td>None</td>
</tr>
<tr>
<td><strong>Clams, oysters, and mussels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cook until shells open during cooking.</td>
<td>None</td>
</tr>
<tr>
<td><strong>Scallops</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cook until flesh is milky white or opaque and firm.</td>
<td>None</td>
</tr>
</tbody>
</table>

*Table sourced from “www.foodsafety.gov”*

**Cooking process** – The cooking process must be capable of achieving adequate temperatures for all products cooked, taking into account the volume of product and cooking time. **A properly calibrated thermometer must be used to verify that minimum temperatures are achieved.** Cooked products should be protected after cooking in order to prevent re-contamination. Lastly, discuss your cooking process with your local and/or state sanitarian to determine if additional licensing and certifications may be necessary to perform certain cooking processes at the farmers’ market or in your processing facility.

**Microwave cooking** – Meat, poultry, seafood, and eggs cooked in a microwave oven must reach an internal temperature of 165°F. In addition, the product must be rotated or stirred throughout or midway through the cooking process, and covered to retain surface moisture. Allow the product to stand for two minutes before taking the temperature, and then take the temperature in at least two of the thickest spots.

**Par-cooking** – or partial cooking occurs when food products are only partially cooked and then are cooked to completion before serving. This technique is gaining popularity because it allows faster preparation times at the point of service. This type of process will require a written process and be approved by a regulatory authority. In that process, the initial heating step should be less than 60 minutes in duration, the product must be immediately chilled, held frozen or refrigerated, and then cooked to the proper temperature prior to service. Speak with your local and/or state sanitarian before using this process to prepare foods for sale at the farmers’ market.

**Chilling** – Any cooked TCS foods which will not be immediately served or hot-held, are required to be cooled to 41°F within a specific time period. Hot TCS foods must be cooled as follows:

- From 135°F to 70°F within 2 hours.
- From 70°F to 41°F within 4 hours.
- A total time of 6 hours to cool from 135°F to 41°F.

**Chilling Techniques**

**Chilling cooked foods rapidly can be accomplished by using the following methods:**

- Place food in shallow pans.
Separate food into smaller portions.
Use rapid cooling equipment.
Stir food in a container placed in an ice water bath.
Use heat transferring containers.
Add ice to the food as an ingredient.

Thawing

The following processes are the approved and safe methods for thawing frozen foods:

- Thaw at refrigeration temperatures.
- Thaw under cool running water (water not to exceed 70°F).
- Thaw in a microwave, but must continue immediately to the cooking process.
- Thaw as part of the cooking process.

For frozen fish packaged in ROP packaging (i.e. vacuum packed), the packaging must be cut before thawing and the fish removed during thawing under refrigeration. If the ROP frozen fish is thawed under running water, the fish product must be removed from the packaging immediately after thawing.

Packaging

The packaging of a food product not only provides protection from contamination, but also acts as a barrier from intentional tampering. Packaging provides a surface for labeling, including the required information about the food product and the company.

While foods can be packaged at the point-of-sale, pre-packaging foods provides some advantages. When packaging in the processing environment, conditions can be better controlled, leading to less opportunities for post-process contamination. In the package, the food is protected against contamination during storage, shipment, and display. Due to these benefits, vendors who pre-package their food products, especially RTE and TCS foods, may have to adhere to less stringent licensing and food safety certification requirements at the point-of-sale. Check with your local and/or state sanitarians to determine the requirements associated with pre-packaging versus packaging at the point-of-sale.

Canning

Glass and Cans – Whether in glass jars or metal cans, canned foods provide long term stability of food products. However, improperly canned foods can become the source of illness associated with Clostridium botulinum. The process of canning foods involves both a heat process and the sealing of food in a hermetically-sealed package.

In the U.S., there are specific regulatory restrictions for canning foods, based upon the type of food which is being canned. Contact your local and/or state sanitarian for more information on regulatory restrictions associated with canned goods.

Low acid canned foods – These are foods with a finished equilibrium pH greater than 4.6 and a water activity greater than 0.85. Examples include canned green beans and canned soups. To can low acid foods, processors must comply with the FDA Low Acid Canned Foods regulations, which requires registering with the FDA and providing details of your canning process.

Acidified Foods – An acidified food (AF) is a low acid food to which acid(s) or acid food(s) are added and which has a finished equilibrium pH of 4.6 or below and a water activity (a_w) greater than 0.85. Examples include pickled cucumbers and salsa. To package acidified foods in cans, processors must
comply with the FDA Acidified Foods Guidance, which also requires providing details of your canning process to the FDA. In some states, canning processors can be registered and inspected through state health or agricultural departments, fulfilling the FDA’s requirements.

The FDA’s Acidified Foods Guidance excludes the following foods from those requirements:

- Acid foods which have a pH 4.6 or below and contain only small amounts, if any, of low acid foods (i.e. apple sauce or canned tomatoes).
- Acidified food products shipped and stored under refrigeration.
- Jams, jellies and preserves which meet the standard of identity under 21 CFR part 150.
- Food products with a water activity less than 0.85 (i.e. peanut butter).
- Carbonated beverages.

Fermented, non-meat, poultry, or egg foods fall outside of the definition of acidified foods, but can still be a risk if the fermentation is not properly completed. Fermentation processes do not need to be registered or filed with the FDA.

Vacuum Packaging

Vacuum packaging machines remove air from a container or bag and create a seal which restricts air and moisture movement. This type of packaging can increase the shelf-life of the product by reducing some spoilage bacteria from growing and reducing the level of moisture loss from the product and oxidation (reaction of the food with oxygen).

While interest in vacuum packaging is increasing, its use requires approval from a local and/or state sanitarian. For certain products, such as vacuum packaged cooked meat, there can be an increased risk of *Clostridium botulinum* or *Listeria monocytogenes*. Contact your local and/or state sanitarian before undertaking vacuum packaging.

Packaging in re-sealable storage bags or containers – Many kinds of re-sealable storage bags exist, with the most common being some variation of a zippered storage bag. The same is true for re-sealable storage containers, such as those used in the restaurant industry. If vacuum packaging is not a feasible option for you, re-sealable storage bags or containers can be a suitable alternative. Like vacuum packaging, re-sealable storage bags and containers also can prevent air and moisture from entering the space inside the bag or container. However, any air left inside the bag or container cannot be fully removed, and depending on the sealing mechanism, air and moisture may still enter. For food items which are not intended to be stored for a long period of time, re-sealable storage bags or containers can be a great way to pre-package foods, prevent contamination, and provide an external surface for labeling.

Other pre-packaging – Butcher paper, plastic wrap, aluminum foil, tissue paper, plastic and paper bags, or other clean and sanitary materials can be used to pre-wrap or protect foods for sale at the farmers’ market. Make sure that these materials are safe for use with food and do not contain any harmful chemicals (i.e. ink from newspapers) that could be transferred and contaminate your food product.

Table 5.2 can help you decide what pre-packaging method may be the most suitable for your food products.
Table 5.2. Packaging Methods and their Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Pre-Packaging Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vacuum packaging</strong></td>
<td>• Increases shelf life.</td>
<td>• Cost of equipment.</td>
</tr>
<tr>
<td></td>
<td>• Removes oxygen necessary for certain bacterial growth.</td>
<td>• Cost of maintenance.</td>
</tr>
<tr>
<td></td>
<td>• Prevents air, moisture, and environmental contaminants from entering the packaging.</td>
<td>• Units may require specialized bags or containers.</td>
</tr>
<tr>
<td></td>
<td>• Prevents freezer burn if food is stored frozen.</td>
<td>• Units may take up a large space.</td>
</tr>
<tr>
<td></td>
<td>• Can be automated.</td>
<td>• Units may not be easily moved or transported.</td>
</tr>
<tr>
<td></td>
<td>• Reduces space needed for storage.</td>
<td>• Unit may require training to operate and maintain.</td>
</tr>
<tr>
<td></td>
<td>• Pre-labeled customized bags are available.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can detect if seal has been broken.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Re-sealable storage bags and containers</strong></td>
<td>• Low cost.</td>
<td>• Larger bags or containers can be higher in cost.</td>
</tr>
<tr>
<td></td>
<td>• Provides some increase in shelf life.</td>
<td>• May not be able to detect if bag or container is fully sealed.</td>
</tr>
<tr>
<td></td>
<td>• Provides some protection from air, moisture, and environmental contaminants.</td>
<td>• May not prevent air and moisture from entering the bag or container.</td>
</tr>
<tr>
<td></td>
<td>• Readily available for purchase at common retail stores.</td>
<td>• May not be able to detect if bag or container was opened.</td>
</tr>
<tr>
<td></td>
<td>• Partially prevents freezer burn if stored frozen.</td>
<td>• Bags and containers must be sealed by hand.</td>
</tr>
<tr>
<td></td>
<td>• Provides surface to hand write or attach label.</td>
<td>• If sealing mechanism is weak, bags or containers may inadvertently open.</td>
</tr>
<tr>
<td></td>
<td>• Bags or containers are easily stored and transported.</td>
<td>• Large or heavy food items may not fit or be able to be sealed properly in certain bags or containers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other pre-packaging</strong></td>
<td>• Low cost.</td>
<td></td>
</tr>
<tr>
<td><strong>(plastic wrap, aluminum foil, butcher paper, tissue paper, or other wrapping, covering, or bagging)</strong></td>
<td>• Readily available for purchase at common retail stores.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can prevent food from directly touching contaminated surfaces.</td>
<td>• Provides limited protection from air, moisture, and environmental contaminants.</td>
</tr>
<tr>
<td></td>
<td>• Provides surface to hand write or attach label.</td>
<td>• Tape or other fastening material is needed to secure or close the packaging.</td>
</tr>
<tr>
<td></td>
<td>• Materials are easily stored and transported.</td>
<td>• May not be able to detect if packaging was opened.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Packaging may inadvertently open or become un-fastened.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• May be difficult to package large or heavy food items.</td>
</tr>
</tbody>
</table>
Labeling

Food labels are necessary to provide ingredient and nutrition information required by state and federal regulations. It is important to understand that USDA-inspected products will require different kinds of labeling information than those inspected by the FDA or exempt from federal inspection. Work with your local and/or state sanitarian to determine the types of labeling information required for your products.

Use the following checklist to help guide you through general labeling requirements.

For non-meat, poultry, and egg products:

- For pre-packaged food items, does the packaging label contain a business name, address, and phone number?
- For pre-packaged food items, does the packaging label follow the FDA food labeling requirements (21 CFR Part 101), if required?
  - General food labeling requirements (statement of identity, net quantity, information panel, principal display panel).
  - Ingredient lists, colors, and food allergen declaration.
  - Nutrition labeling.
  - Cooking and handling instructions.
- For food items packaged at the market, are consumers provided with business information (name, address, phone number) in some manner (detailed receipt, business cards, labeled packaging or bags, signage)?
- For food items packaged at the market, are the required FDA food labeling information provided in some manner (signage, brochures, labeled packaging or bags), if required?

For meat, poultry, and egg products:

- For pre-packaged meat, poultry, and egg products, does the packaging label contain a business name, address (including city, state, zip code), and phone number?
- For pre-packaged food items, does the packaging label follow the FDA food labeling requirements (9 CFR 312.3, 317.2(i), 381.96), if required?
  - General food labeling requirements (product name, net weight).
  - Ingredient lists, colors, and food allergen declaration.
  - Nutrition labeling.
  - USDA inspection legend, including establishment number.
  - A handling statement and/or safe handling instructions.
  - If exempted poultry product, (Exempt P.L. 90-492).
- For meat, poultry, and egg products packaged at the market, are consumers provided with business information (name, address, phone number) in some manner (detailed receipt, business cards, labeled packaging or bags, signage), if required?
For meat, poultry, and egg products packaged at the market, is the required USDA food labeling information provided in some manner (signage, brochures, labeled packaging or bags), if required?

Transportation

Food must be transported in a way that protects food from contamination, as well as ensures proper temperature control for TCS foods. These same considerations also apply to any utensils, equipment, or other tools which will be used to handle food products at the farmers’ market.

Before transporting food to the farmers’ market, follow these steps to reduce the risk of cross-contamination during transportation:

- Clean and sanitize any containers or surfaces used to store food during transport, before food is transferred to these areas.
- If handling food items and moving them from storage areas to transport containers, do so in a clean area, make sure all employees have washed their hands properly or are using disposable gloves, and are following good hygienic practices.
- Clean or cover truck beds and interior vehicle spaces before using them for food transport. Make sure these spaces are dry and free of harmful chemicals.
- Use secondary containers to prevent food items from coming into contact with dirty vehicle surfaces.
- Monitor transport containers used to store cold or hot foods with a thermometer to ensure food items remain at proper storage temperatures during transport.
- Bring extra ice or other cooling and hot holding equipment.
- Keep raw foods, RTE foods, and TCS foods physically separated during transport to avoid cross-contamination.

Point-of-Sale Preparation: Preparing food on-site at a Farmers’ Market can present a number of challenges, including the following:

- Un-cleanable or difficult to clean surfaces associated with temporary facilities (walls, floors, and ceilings).
- Lack of washing facilities to properly wash food, utensils, and equipment.
- Lack of electrical power for operating storage or food processing equipment.
- Lack of proper refrigeration or frozen storage equipment.

Each farmers’ market site will offer its own unique challenges, and preventing cross-contamination and reducing food safety risks at the farmers’ market will take planning and practice. It is important to evaluate the limitations of the farmers’ market site, and understand what tools and methods you will have to use to ensure safe food preparation and sale on site. The next chapter will provide some guidelines and tips for managing specific challenges and risks for preparing and selling foods at the farmers’ market.
Chapter 6: On-site Handling, Service, and Sales – Maintaining the Bottom Line While Keeping Customers Safe

This chapter presents key areas for on-site handling, service, and sales at the farmers’ market.

- Maintaining sanitary conditions at the farmers’ market
- Food product display
- Packaging at the market
- Food samples
- Handling money
- Customer interaction
- The market manager

Farmers’ market operations present some of the biggest food safety challenges, especially for the preparation and handling of TCS and RTE foods. There will be increased exposure to the environment, a lack of infrastructure, and the pressure of dealing with a large number of customers. Taking the time to plan and prepare a “point-of-sale” food safety plan can be vital to ensuring a safe and profitable experience.

Maintaining sanitary conditions at the farmers’ market

Farmers’ markets occur in a wide variety of settings and structures. A market stand can range from a canopy structure located in a field with no water or power, to a booth in a conventional building located in an urban center, with running water, washing sinks, and electrical power. Vendors must plan ahead to address the unique challenges faced at each farmers’ market, taking into account their products and the utilities needed to keep their products safe.

The following guidelines can help put into practice many of the food safety concepts discussed in the previous chapters at the farmers’ market:

- Follow a developed cleaning and sanitizing plan to include procedures for set-up and breakdown, routine cleaning, and sanitizing. This plan also should take into account how to handle spills or other unexpected hazards.
- Have necessary cleaning equipment and materials (i.e. bucket, water, soap, sanitizer, brush, paper towels) available.
- Have extra tablecloths or surface coverings in the event of a spill or damage to those materials.
- Inspect all of your processing and vending equipment (i.e. table, tent, display cases, coolers) prior to the market day to ensure they are working properly.
- Ensure your employees are trained and understand the procedures and practices in place to maintain a sanitary and safe vending area.
- Monitor cleaning and sanitizing procedures and employee hygiene practices throughout the market day.

In many cases, important utilities may not be available at the farmers’ market, such as a warewashing sink or a handwashing sink, but simple systems can be constructed to address these challenges.
Making a warewashing sink – If a warewashing sink will be required, but not provided by the farmers’ market, one can easily be assembled using three large buckets, potable water, soap, sanitizer (i.e. bleach), cleaning tools (brush or towel), and a drying rack or cleanable surface to dry items.

- Fill the first bucket with soapy water for washing.
- Fill the second bucket with fresh water for rinsing.
- Fill the third bucket with a sanitizer solution (follow the manufacturer’s instructions for proper concentration).
- Set up a drying rack on a clean and sanitized surface or hand dry with disposable paper towels.
- The temporary warewashing sink should be located away from the sales area and food vendors, and close to a public sewer or established draining area.

*Before using a temporary warewashing sink, check with the local municipality and property owner to determine the criteria for disposing of used wash water.*

Handwashing stations – A handwashing station is an important tool to help reduce food safety risks at the farmers’ market. In general, handwashing sinks will be required for use during raw food handling and preparation, with the exceptions of selling pre-packaged foods or raw agricultural commodities, such as produce from the field.

Due to the recent growth of farmers’ markets, many state public health have instituted policies requiring access to, temporary handwashing stations at farmers’ markets without permanent structures. There are many affordable options for establishing a handwashing station. Units can be purchased (even online) or a simple system can be constructed consisting of a water container with a controllable spout, a waste bucket, hand soap, and paper towels.

*When setting up a temporary handwashing station at the farmers’ market, consider some of the following guidelines:*

- The hand washing station should be easily accessible for the employees and/or customers, but far enough away from your food products to avoid potential contamination from splashing water.

- The water container should be easily opened and closed and raised high enough to be used effectively.

- Tie down or weigh down your water container, table, and waste bucket to ensure they don’t fall down, blow away, and spill onto your vending table or food products.

- Bring extra water, soap, and paper towels and ensure they are accessible at all times.

- Monitor your hand washing station throughout the market hours and ensure water, soap, and paper towels are readily available. Remove waste water frequently into a public sewer system or an approved drainage area.

- Access to handwashing stations for customers should be considered.

*In states or local municipalities which require the use of handwashing stations at farmers’ markets, local and/or state sanitarians may permit multiple vendors to share the use of one or more handwashing stations.*
stations to comply with food safety requirements. Work with the market manager, other vendors, and your local and/or state sanitarians to determine the requirements, and find a hand washing station solution that works for you.

**Food Product Display**

Displaying your food products is important for marketing, but it presents opportunities for contamination. It is important to set-up displays in a way that does not increase the risk of contamination.

**The vending table** — Food can be displayed on a number of different surfaces, including wooden stands, plastic folding tables, and even out of a cooler. Surfaces should be cleaned and sanitized before using them for food displays. Surfaces which cannot be properly cleaned and sanitized can be covered with clean disposable coverings or cleanable re-usable coverings like a table cloth.

**Here are some suggestions to keep a clean and sanitary vending area:**

- Use plastic and metal tables, stands, coolers, trays, and other food contact surfaces, instead of wood surfaces. Wood surfaces are difficult to clean and sanitize properly and can be sources of contamination.

- Cover those surfaces with a clean re-usable or disposable table cloth or surface covering. If disposable, throw away at the end of the day and do not re-use. If the covering is cloth or other reusable material, launder with detergent or bleach before using again.

- Have cleaners, sanitizers, and supplies (i.e. bucket, brush, sponge, paper towels) available at the market to clean up unexpected spills or soiled areas.

- Have disposable paper towels on-site and a trash bag to dispose of dirty paper towels and trash.

- If using a cloth towel to repeatedly clean and sanitize surfaces at the farmers’ market, make sure the towel is cleaned, sanitized, and rinsed thoroughly after and before each use. Store away from the vending area and hang it, allowing it to air dry away from clean surfaces.

**Displaying and presenting food** — Even a clean vending surface may not prevent customers or the farmers’ market environment from introducing contaminants of their own.

**Use the following guidelines to keep foods displayed for sale safe and sanitary:**

- Use “display foods” to show which foods are available for sale, but are not sold. Keep the for-sale items in a clean and sanitized storage container, or cooler if temperature sensitive, and make sure these items are only accessed by you, the vendor.

- Do not place un-packaged foods directly onto a vending table without a covering; use secondary coverings or other clean and sanitized containers.

- Protect un-packaged food products from the environment: keep them off the ground; cover to protect against insects; and shield against direct sunlight.
• Prevent customers from touching un-packaged foods (especially TCS foods) with bare hands. Provide utensils or sanitary tissues for handling un-packaged foods or by covering those items with a clear covering (i.e. cellophane wrapping).

• Provide an easy-to-reach hand washing station, hand wipes, or hand sanitizer for customers, and request that customers use them before and after handling foods products.

• If selling foods requiring cold storage, do not leave coolers open for display; utilize “display foods” as described above.

• Keep a visible and easy-to-read thermometer in each cold storage container to ensure proper temperature control.

Packaging at the Market

If food is going to be packaged at the market, it is important that you utilize a packaging method which prevents contamination from employees, customers, and the farmers’ market environment, while allowing the customer to transport the food item safely.

Follow these general guidelines to reduce the risks associated with selling un-packaged foods at the farmers’ market:

• If providing bags for customers, only use new, clean, and sturdy bags, capable of holding the weight of your food products without breakage or leakage. Double bagging is recommended for heavier items.

• Assign one employee to perform all of the product handling and bagging and another employee to handle money, receipts, or perform other tasks which may introduce contamination.

• Provide customers with safe transport and storage guidelines for the specific foods they purchased (i.e. separate raw meat from produce, keep raw chicken below 41°F), as well as safe cooking instructions, if needed.

• Have inexpensive, temporary Styrofoam™ or similar style coolers for sale, if customers do not have a method of keeping foods cold during their transport home.

Develop a System of Packaging to Prevent or Minimize the Risk of Bare Hand Contact — Procedures used for packaging food should minimize the risk of contamination. Handwashing and minimizing bare hand contact are essential.

Minimizing bare hand contact can be achieved through use of disposable gloves or through these strategies:

• Use the “inside-outside bag technique.” This method involves using clean and unused plastic bags, in which the vendor places their hand inside the bag, grabs the item to be packaged, and pulls the bag and item through, turning the bag inside out and eliminating any contact between the food and the bare hand.
Use produce bags, butcher paper, tissue paper, plastic wrap, foil, baking sheet, or any other wrapping material used commonly in food preparation to grab, handle, and wrap food products, without touching the product with bare hands.

Food Samples

Serving samples of food products at the farmers’ market can be an effective way to attract customers by allowing them to try the various types of foods offered. Depending on the types of food products served, there may be specific risks and requirements that must be considered to ensure the safety of food samples during their preparation and serving.

*Serving food samples is not the same as performing a cooking demonstration. Cooking demonstrations, in which vendors prepare foods for sampling by customers, may require a ready-to-eat vendor or retail food operator license. Check with your local sanitarian for more information.*

Food sample preparation – The best way to ensure the safety of food samples is to prepare them before arriving at the market.

Follow these additional guidelines for preparing food samples *before* arriving at the market:

- Check with the local and/or state sanitarian and your market manager to determine any requirements to serve food samples at the farmers’ market.
- Follow food safety preparation procedures specific for that food product.
- Keep prepared food samples covered and stored in a sanitary manner, and store or package them so they may be easily transported and handled without increasing the risk of cross-contamination.
- Any prepared food samples requiring refrigerated or hot-held storage, should be kept in those conditions at all times, including transportation to the market.

Although preparing food samples *before* arriving at the market is a good strategy to ensure the safety of any sampled food items, you can prepare food samples successfully at the farmers’ market by following these additional guidelines:

- Check with the local and/or state sanitarian, as well as the market manager, for any requirements in order to prepare the specific type of food samples. For example, there may be specific regulations required for heating, cooking, or serving RTE items, even if they are samples.
- Before preparing food samples on site, clean and sanitize the food preparation surfaces. Utilize secondary surfaces, such as a plastic cutting board, to ensure food items do not come into contact with dirty surfaces.
- Wash hands before handling and preparing food samples and wear gloves, as required for RTE products. Hand sanitizers by themselves are not sufficient. Continue to change gloves and wash hands periodically, and anytime hands become contaminated by touching a dirty surface, handling money, etc.
• Ensure that any utensils or kitchenware used to prepare food samples at the market have been cleaned and sanitized. If they will be used throughout the day, ensure they are cleaned and sanitized at least every 4 hours or any time they become contaminated by touching an unclean surface. It may be helpful to have several sets of utensils available, in the event a utensil falls on the ground and quick action is needed.

• Place utensils on a clean and sanitized surface. If surfaces cannot be cleaned or have been soiled, place utensils on a clean plate or dish.

• If using portable food processing equipment to prepare food samples, ensure the equipment is working properly before arriving at the market to achieve the desired result (i.e. heat or cool foods to required temperatures).

• Dispose of food preparation waste into an easily accessible trash bag.

Serving samples – At the market, food samples must continue to be handled in a sanitary manner after they are prepared and displayed.

Follow these guidelines when serving food samples at the farmers’ market:

• Serving customers individually is the best way to ensure samples are properly handled by the customer.

• Servers must wear disposable gloves properly and/or wash their hands before handling food samples and re-wash as necessary. Hand sanitizers by themselves are not sufficient, but can be used to supplement handwashing.

• Use clean and sanitized utensils to handle and/or serve food samples for customers.

• If food samples are self-served, ensure they are placed onto clean and sanitized trays, plates, or bowls, or into individual disposable serving cups. Food should be covered to prevent contamination.

• Provide easily accessible toothpicks, tongs, or disposable serving utensils to customers, and ensure they are utilizing them to handle samples. By preparing food items with toothpicks or serving utensils already in or on samples, customers are more likely to use them.

• If food samples require refrigerated storage, keep serving trays, plates, or bowls on ice or in a cold storage device capable of keeping product cold until the food is served.

• Throw away any un-eaten food samples at the end of the market day, and do not re-serve samples from a previous day.
Handling Money

Paper money, coins, and plastic credit cards can be sources of potentially harmful bacteria and viruses. Although the risks are low, research has demonstrated that harmful bacteria can be present on money. By simply touching a contaminated dollar bill, any harmful organisms present on the surface of that dollar can be transferred easily to a person’s hands, and anything that person may touch afterwards. Due to this risk, food handlers must make certain precautions when handling both money and working with food.

Cash registers and credit card machines – Farmers’ market vendors utilize a variety of money transaction devices including cash registers, portable credit card machines, smart-phone or tablet credit card swiping devices, or written receipts. Just like money, these devices can be sources of harmful bacteria and viruses. Therefore, these devices should be sanitized in some manner. A money handling plan should be developed, incorporating procedures for handling money and sanitizing devices.

If the food products are pre-packaged, there is no concern for contamination from money, provided the food is not exposed. But when handling unpackaged food, hand washing is necessary after handling money. Continual handwashing after each transaction may be difficult, so this should be included as part of your money handling plan.

The following are methods to use as part of a money handling plan:

- Clean and sanitize surfaces of cash registers, credit card machines, or smart-phone and tablet devices before your first transaction and periodically throughout the day. (Contact the manufacturer of your equipment to determine acceptable cleaning and sanitizing agents). Disposable sanitizer wipes, containing bleach or other sanitizer, can be a suitable way to sanitize those surfaces quickly.

- When wearing disposable gloves to handle un-packaged RTE foods, remove gloves to handle money and/or touch registers and/or credit card machines, and then wash hands and put gloves back on before handling food products.

- Designate one individual to handle all money transactions, and another individual to handle food products, packaging, or bagging.

- Use clean utensils (tissue or butcher paper, inside-outside plastic bag technique, or another method) for handling food, especially when using gloves may be too cumbersome.

Receipts – Providing customers with receipts for purchased food items is an important business practice for recording a transaction at the farmers’ market. This information can be critical during a foodborne illness outbreak or a recall. The receipt also provides customers with business contact information.

Although a printed or electronic receipt is ideal, a written receipt with the following information is suitable:

- The name of your business, address, and telephone number.
- The name of the person who made the purchase (optional).
• The date of purchase.
• Item description, quantity, and batch or item number, if present.
• Record the amount of purchase.
• List the method of payment used to make the transaction.
• Include subtotal, taxes if necessary, and total amount of purchase.
• If a credit card was used, list the name on the card and the last four digits of the card number (optional).
• Sign the receipt (as the vendor) and mark with a statement such as “paid in full.”
• Make a copy of the receipt for your records.

Customer Interaction

Farmers’ market vendors may experience times at the market when they are overwhelmed with potential customers. These are the times when the risk of foodborne illness increases, and when vendors must give extra attention to their food handling practices.

The following are methods to help maintain food safety and manage heavy customer traffic:

• Pre-packaging your food items is not only a great way to ensure food safety, but it can eliminate the need for further packaging and save time during peak market hours.

• Adding additional employees at those peak hours can help manage large crowds. Ensure these employees are trained and understand the food safety systems in place.

• Designate employees to perform specific tasks (handling money, packaging product, etc.), rather than having each employee perform all tasks.

• At the stand, segregate and/or identify areas for displaying food products and/or money transactions. This approach will help prevent customer bottlenecks.

• Provide customers with instructions, through signage or labels, rather than verbally communicating with each one on how to handle or not handle the foods they purchase.

• Schedule break times so that all workers are available for peak periods.

Providing customers with food-related information – Brochures are a great way to market your products and provide background information. Brochures also can be a great way to share nutrition and food safety information. To maintain the trust of customers, it is important that the information on the brochures be factual, up-to-date, and supported by peer-reviewed science.
The following are some guidelines to provide useful, factual, and up-to-date information:

- Contact your local Cooperative Extension office for nutrition and food safety information that are product-specific.

- The internet can be a source of misleading or false information. News articles, personal websites, blogs, private organization reports, social media sites, or non-peer reviewed scientific articles are not considered reliable sources of information.

- Reliable sources for scientific information include state or federal government agencies (i.e. PDA, USDA, FDA, CDC) or academic institutions. Peer-reviewed, scientific journal articles, academic institution reports, or peer-reviewed, trade organization reports also can be used, but it is best to utilize information that has been vetted by trusted sources.

- Use the most current information (preferably something that has been reviewed within the last five 5 years).

- If the topic is controversial, is not validated, or has to the potential to be misconstrued, you may want to reconsider sharing it with your customers due to liability issues.

- Ensure that brochures, pamphlets, or general information are reviewed by an expert before distributing. Contact your local Cooperative Extension Office, local or state health or agricultural departments, or federal district offices (i.e. USDA, FDA) for their assistance.

- If customers ask something that you can’t answer, it’s better to say that you do not know, rather than making up information. It’s important to provide customers with information from reliable sources.

The Market Manager

The market manager holds a unique and important role, which is vital to the success of a farmers’ market. As a farmers’ market vendor, the market manager may be the first contact for all things related to that specific farmers’ market.

When it comes to food safety, keep the market manager up-to-date on the types of products you plan to sell as well as any food safety protocols that will be used. Inform them of licenses, inspections, or any food safety regulatory issues that may impact your business. In many cases, other vendors may be facing similar challenges, or may have found solutions to those problems, and the market manager can be key to communicating those issues to everyone at your market.
Chapter 7: Procedures and Records, Traceability, and Liability – Protecting the Business through Management and Planning

This chapter presents key areas for the procedures and records, traceability, and liability associated with foods produced for sale at farmers’ markets.

- Procedures and Records
- Traceability
- Recalls
- Liability and Insurance

**Procedures and Records**

**Procedures**

Developing, writing, and following dedicated procedures for the preparation and processing of food is key to sustaining a safe and successful food business.

**Having dedicated procedures for the many steps or processes associated with preparing and selling food at farmers’ markets can have the following benefits:**

- Ensures food safety practices aren’t forgotten.
- Helps to maintain consistency of food products sold.
- Provides regulators with the information they need to inspect and regulate your operations.
- Can be used to train other personnel or new employees.

Depending on the size and scope of the food production and sales operations, procedures can be developed for a wide variety of processes and applications.

**Examples of activities in which procedures could be developed include:**

- Preparation or processing of specific food products.
- Cleaning and sanitizing programs.
- Personal hygiene programs.
- Produce harvest and packing.
- Post-harvest washing or culling.
- Farmers’ market set-up/break-down (See Appendix 2 for an example of this procedure).
- Facility and equipment maintenance.

**Records**

Keeping records associated with the procedures developed and in place ensures food safety practices are being followed.

**Keeping and maintaining records for the procedures developed can have the following benefits:**

- Provides proof that a particular task was completed.
- Ensures food safety procedures and practices were performed within acceptable limits (i.e. temperature, sanitizer concentration).
- Demonstrates to regulators that procedures are being followed and taken seriously.
- Can provide critical information needed during recalls and outbreaks.

Depending on the procedures developed and in place, records can be maintained for a wide variety of procedures and tasks.

**Examples of information to be recorded and maintained on dedicated records include:**

- Produce harvest field/plot/personnel information.
- Storage temperatures and conditions.
- Cleaner and sanitizer parameters.
- Cooking and processing parameters.
- Ingredient information.
- Farmers’ market set-up/breakdown tasks.
- Personnel training.

**Traceability**

**Traceback or traceability** is the ability to track food products throughout the supply chain and back to their originating sources (i.e. growers, packers, processors). Even in small scale operations, maintaining a traceback system and records of product produced and sold, can be vital in emergency situations. The use of a traceback system won’t prevent foodborne illness from occurring, however it will provide the ability to rapidly identify the source of a contaminated food product during a foodborne outbreak.

Unfortunately, recalls and outbreaks have been associated with foods sold at farmers’ markets, and in those instances, the lack of traceback systems and records, have made it difficult to identify contaminated foods and notify the public in time to prevent further illness. In general, traceback systems should be comprised of documentation which can indicate the source of a product and identification that can follow the product from the farm to the consumer.

**For producers of raw agricultural commodities**, farmers should, at a minimum, maintain records which identify the following items on individual or lots of raw agricultural products:

- Date of harvest.
- Farm/field/plot identification.
- Workers or handlers of the raw agricultural product.
- Date and location of sale.

For food processors that use commercially-obtained ingredients, it is also important to monitor the FDA or USDA recall announcements and implement a system to track and record ingredient information for each batch of food product produced. In case of a recall or outbreak associated with those ingredients, a tracking system will be needed to identify if food products produced and sold contained the recalled ingredient.

**The following tasks should be performed if notified of an ingredient recall:**

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• Follow the federal or manufacturer’s recommended actions listed on the recall announcement.

• Remove those items from the processing area, and label them to ensure they are not used for further processing.

• Implement a recall plan if the recalled ingredient was used in a produced and/or sold food product.

Recalls

Recall – A food recall is a system or the action of removing food products from commerce or distribution that are either in violation of the law or pose a public health risk. Although food products sold at farmers’ markets are seldom involved in recalls, there have been several documented cases of food recalls associated with farmers’ markets in the U.S.

As a farmer or small food processor who sells foods at farmers’ markets, it is important to have an established and practiced system in place to be able to traceback a specific product or lot of products, and implement a notification system to customers who may have purchased the effected item. Recalls are typically implemented when a food processor or a regulatory agency identifies a hazard (i.e. food tests positive for pathogen, food contains and undeclared food allergen) before or after the sale and distribution of that product, or in the case of a foodborne outbreak.

During a recall, the public health agency involved will likely require the following information:

• Identity of the product involved in the recall.

• Reason for the removal or correction and the date and circumstances under which the food product deficiency or possible deficiency was discovered.

• Evaluation of the risk associated with the deficiency or possible deficiency.

• Total amount of such food products produced and/or the time span of the food production.

• Total amount of such food products estimated to have been sold or distributed.

• Distribution information, including the number of sales, location of sales, and any information on customers who purchased the food item.

• A copy of a recall announcement, if any has been issued, or a proposed communication if none has been issued.

• Proposed strategy for conducting the recall.

• Name and telephone number of the food establishment representative who should be contacted concerning the recall.
Insurance and Liability

Following proper food safety practices, obtaining proper licensing, training, and certifications are not only important to keep customers safe, but they are key elements in protecting your business. With the relatively rapid increase in farmers’ markets in the last decade, many farmers now have a powerful outlet to sell their agricultural products direct to consumers, without the use of brokers, grocery stores, or other elements of the commercial food system.

One of the growing concerns within the farmers’ market and state level agricultural community is the liability associated with direct-to-consumer sales at farmers’ markets and similar venues. Although few outbreaks, consumer injuries, or other legal cases have affected farmers’ markets in the U.S., it is becoming apparent that farmers and vendors may be vulnerable, without the necessary insurance.

Farm liability insurance – Recent reviews of liability concerns associated with farmers’ markets have revealed that the typical farm liability insurance held by most farmers will not protect vendors from incidents occurring at the farmers’ market, and in some cases, not cover injury or illness associated with “on-farm” sales.

Obtaining additional liability insurance – Farmers and food processors, who sell food products at farmers’ markets or other related venues, should consider obtaining additional liability insurance to protect themselves in instances of injury or illness associated with the sale or consumption of the food products sold at their food stand. It is important to realize that in a legal case involving foodborne injury or illness, the farmers’ market vendor selling food to the public will likely be held to the same food safety standards as any major food retailer or processor. It is critical that farmers and small food processors consider seeking additional liability insurance before moving into the production and sale of food for sale at farmers’ markets.

During the search for liability insurance, ensure that all aspects of the farm or food processing business are discussed with the insurance provider. Hiding activities or giving minimal details of the operation may result in gaps in coverage. Never assume that other insurance policies will overlap or cover gaps in another policy. It is important to ask insurance providers to explain the details of a particular policy, and clearly identify what is covered and what gaps may exist. It also may be beneficial to discuss potential illness or injury scenarios with those providers, which may be helpful in understanding which policies may be most suitable.

Inform the market manager and farmers’ market association of insurance coverage – Farmers’ market vendors should discuss liability concerns with market managers or the associated farmers’ market association. Although many farmers’ market associations will require vendors to have additional insurance, others may not. It is important to understand that in the case of a consumer injury or illness related to a food product sold at a farmers’ market, the vendor, the market, and the market manager may all be held liable in various degrees. Managers responsible for markets held on public land should also determine whether the local municipality requires liability insurance and what laws may exist to protect the vendor or the municipality in the case of a consumer illness or injury.
Appendix 1 – Set-Up and Breakdown Checklist

The set-up and breakdown procedures at the farmers’ market should be well planned to ensure that food is properly handled and that nothing is overlooked. Use the following checklist to ensure proper procedures and precautions are used to maintain sanitary conditions during the set-up and breakdown at the farmers’ market.

**Set-up**

- Clean and sanitize all food contact surfaces (or cover with clean materials), before removing prepared food items from storage.
- Have cleaning and sanitizing supplies handy and available.
- Ensure hand washing stations, hand sanitizer or wipes, and food-safety-related signage are easily accessible to both workers and customers.
- Make sure food items are protected from potential environmental contaminates (i.e. rain, dirt, dust, sun).
- Ensure vending tables and tents are tied down securely to prevent the wind from blowing food, utensils, and other supplies around or onto the ground.
- Display the minimum amount of food products necessary to complete the vending display; keep additional food products stored properly until needed.
- Use a thermometer to verify that cold or hot storage containers or displays are holding the correct temperatures, and that TCS foods remain at proper safe temperatures.
- Review all of food safety-related plans and protocols with employees before the market hours begin.
- Establish set times for breaks.
Breakdown

Before packing un-sold food items, ensure all storage containers and _____ utensils have been cleaned and sanitized.

Throw away any food items which may have become temperature abused (if temperature sensitive), spoiled, or otherwise adulterated, due to _____ conditions at the market.

_____ Throw away any un-eaten food samples.

Use a calibrated thermometer to verify that cold or hot storage containers are holding the correct temperatures, and that temperature sensitive foods remain at proper safe temperatures for transport (refill with ice as _____ necessary).

_____ Review any challenges or issues related to your food safety plan with your employees and discuss how they may be solved in the future.
Appendix 2 – Methods for Calibrating Thermometers

The calibration of thermometers used in food production and preparation is key to ensuring that the instruments used to measure temperature for cooking and cooling processes are working properly. Although some thermometers cannot be manually calibrated, it is still important to verify the accuracy using the following methods below. Thermometers which can be calibrated, such as bimetallic thermometers, can be adjusted using the hex adjusting nut below the thermometer viewing head. Thermometers are considered accurate when they register plus or minus (+/-) 2 degrees from the actual temperature being measured.

**Calibration in Ice Water:**

1. Mix water and crushed ice in a large glass.
2. Immerse the stem or probe portion of the thermometer into the ice water mixture for 60 seconds.
3. The thermometer should read 32°F. If the thermometer is adjustable, keep the thermometer in the ice water, and use a wrench or tool provided to turn the hex adjusting nut until the dial reads 32°F. If the thermometer is not adjustable and is more than 2°F off, remove from use or return to the manufacturer to be calibrated.

[Image of a thermometer in ice water]

**Calibration in Boiling Water:**

1. Fill a pot or container with water and bring to a boil.
2. Immerse the stem or probe portion of the thermometer into the boiling water for 60 seconds.
3. The thermometer should read 212°F. If the thermometer is adjustable, keep the thermometer in the boiling water, and use a wrench or tool provided to turn the hex adjusting nut until the dial reads 212°F. If the thermometer is not adjustable and is more than 2°F off, remove from use or return to the manufacturer to be calibrated. *Note: Altitude will change the temperature at which water boils, so make adjustments accordingly.*
Appendix I

Farmers’ market vendor food safety pilot training program power point presentations
Appendix I. Farmers’ market vendor food safety pilot training program power point presentations

Chapter 1: Understanding the risks

Slide 1-2

FARMERS' MARKETS AND FOODBORNE ILLNESS
UNDERSTANDING THE RISKS

Penn State Extension
Food Safety at Farmers’ Markets
Foodborne illness risks associated with farmers’ markets:
• Contamination can occur anywhere in the food chain.
• Food operations often extend from the field to the consumer.
• The complexity of food processing performed can vary.

Slide 3-4

Food Safety at Farmers’ Markets
While many operations start with selling basic food commodities (i.e., produce) at farmers’ markets, they can move into selling more value-added products. This can change the operational requirements for:
• Facilities
• Equipment
• Processes
• Procedures

Slide 5-6

Food Safety at Farmers’ Markets
This training will address food safety across the supply chain:
1. Foodborne Illness at a Farmers’ Markets – Understanding the Risks and Regulations
2. Food Safety Basics
3. Facilities, Equipment, Water, and Garbage Disposal
4. Sourcing and Purchasing
5. Product Processing and Preparation
6. On-site Handling, Sales and Service
7. Procedures and Records, Traceability, and Liability

Penn State Extension
Foodborne Illness in the U.S.
According to CDC, foodborne illness results in:
• 48 million people sick
• 128,000 hospitalizations
• 3,000 deaths

CDC – US Centers for Disease Control and Prevention
Foodborne Illness in the U.S.
- An outbreak is when two or more people become ill from eating the same contaminated food.
- Sporadic cases can also arise due to unreported or unidentified foodborne illness.
- The majority of foodborne illness cases are sporadic in nature.

Foodborne Illness Outbreaks at Farmers’ Markets
- 2014 (Michigan) – STEC E. coli outbreak (4 ill), apple cider.
- 2014 (CA) – Salmonella outbreak (14 ill), cheese.
- 2012 (PA) – Campylobacter outbreak (38 ill), raw milk.
- 2011 (Oregon) – STEC E. coli (16 ill, 1 death), strawberries
- 2010 (Iowa) – Salmonella (25 ill), guacamole, salsa and tamales.

Foodborne Illness and High Risk Groups
Farmers’ market customers often include those considered high risk:
- Elderly
- Infants and preschool aged children
- Pregnant women and their fetuses
- People on certain medications
- People with certain diseases that weaken the immune system (immuno-compromised)

Foodborne Illness and Costs
Foodborne illness has financial consequences:
- Medical costs
- Lawsuits
- Negative media exposure
- Loss of customer trust
- Effects spread to other merchants associated with the market, or selling similar foods.

Understanding the Risks
The three types of contaminants:
- Physical
- Chemical
- Biological

Physical Contaminants – Sources and Controls
Objects which get incorporated into a food can cause harm if eaten.
Physical contaminants can include:
- Glass shards
- Metal shavings
- Hard plastic pieces
- Fruit pits
- Bones
- Fingernails
Physical Contaminants – Sources and Controls

Controls - adhere to specific procedures to prevent accidental contamination of physical contaminants, including:

- Using shields on glass bulbs.
- Removing jewelry and other loose personal items.
- Preventative maintenance of equipment.
- Visually inspecting ingredients.

Chemical Contaminants – Sources and Controls

Chemicals which get incorporated into a food can cause harm if eaten.

- Chemical contaminants include:
  - Mycotoxins (mold toxins)
  - Pesticides
  - Cleaners and sanitizers
  - Lubricants
  - Metals (from leaching)
  - Allergens

Allergens – proteins contained in certain foods that cause an abnormal immune response in certain people.

- Peanuts
- Tree nuts
- Crustacean shellfish
- Fish
- Dairy
- Soy
- Wheat
- Eggs

Biological Contaminants – Sources and Controls

Pathogenic microorganisms which if present in foods can cause illness when eaten.

Four types of biological contaminants include:

- Bacteria
- Viruses
- Parasites
- Mold
Biological Contaminants – Sources and Controls

Viruses:
- Norovirus
- Hepatitis A

Parasites:
- Trichinella spiralis
- Giardia
- Cryptosporidium

Mold:
- Various species that produce mycotoxins

Food can become contaminated for a number of reasons:
- Improper processing:
  - Undercooking
  - Improper cooling
  - Improper holding
- Cross contamination
- Poor personal hygiene
- Contaminated ingredient or packaging material

While any food can be the source of contamination, there are two special categories:
- Foods that support the growth of microorganisms – TCS Foods (Temperature Control for Safety) also known as PHF (Potentially Hazardous Foods).
- Foods that have been cooked or prepared and ready to be eaten – RTE (Ready-to-Eat Foods).

To control microbial pathogen growth in food you must understand and use procedures to control the parameters needed for survival and growth:
F-A-T-T-O-M
Food, Acidity, Temperature, Time, Oxygen and Moisture

Food – microorganisms need the right nutrients to grow.
- Protein and carbohydrates are the two most important food components.
- Milk and meat products are examples of products with ample nutrients to support growth of bacterial pathogens.

Acidity (pH)
Acidity is best described by pH where pH 7.0 is called neutral, an acid is less than pH 7.0, and an alkaline or base is greater than pH 7.0.

pH scale:
1 2 3 4 5 6 7 8 9 10 11 12
-----acid-----neutral---alkaline-----
- Pathogens grow well between pH of 4.6 and 7.5
- Control of microorganisms = pH < 4.6
- Meat and poultry have pH of 5.1 to 6.4
Time and Temperature

Time and Temperature – bacterial pathogens will grow over a certain amount of time if temperature conditions are right.

Temperature Danger Zone (TDZ) - 41ºF to 135ºF
- Keep foods which require temperature control out of the TDZ (at farmers’ markets, it is not always possible).
- Follow procedures for how long foods can be held in the TDZ.
- Time and temperature are the parameters that food handlers have more control over.

Oxygen Level

Microorganisms have different requirements for how much oxygen they need or don’t need for growth.
- The biggest concern is for bacterial pathogens that grow in the absence of oxygen such as Clostridium botulinum.
- A lack of oxygen is a concern for Reduced Oxygen Packaging (ROP) which includes vacuum packaging.
- Vacuum packaging is becoming popular with Farmers’ Market vendors.

Moisture

- Water activity is the term used to describe water in foods, and is not the same as the amount of moisture in a food.
- Water activity indicates the level of available water (free water versus bound water).
- Microorganisms vary in their requirements for available water.

Mold < Yeast < Bacteria

--- increasing moisture

Water Activities of Common Foods

<table>
<thead>
<tr>
<th>Moist free</th>
<th>Mostly free</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Distilled water</td>
</tr>
<tr>
<td>0.95</td>
<td>Fresh and canned fruits or vegetables, meat, fish</td>
</tr>
<tr>
<td>0.85</td>
<td>Juice concentrate, dry cheese, margarine</td>
</tr>
<tr>
<td>0.70</td>
<td>Peanut butter</td>
</tr>
<tr>
<td>0.65</td>
<td>Rolled oats, jellies, and jams, molasses, nuts</td>
</tr>
<tr>
<td>0.60</td>
<td>Dried fruits, caramel, toffee, honey</td>
</tr>
<tr>
<td>&lt; 0.60</td>
<td>Beef jerky, noodles, spices, cookies, crackers</td>
</tr>
</tbody>
</table>

Temperature Control for Safety (TCS) Foods

- Foods that meet FATTOM conditions will support the growth of bacterial pathogens, and will require special storage and handling.
- TCS Foods / PHF Foods (Temperature Control for Safety / Potentially hazardous foods) means a food that requires time/temperature control for safety to limit pathogenic microorganism growth or toxin production.
Ready-To-Eat (RTE) Foods
Foods sold or served to a customer without any further preparation by that customer.
- Special care must be taken because any contamination on a RTE food will be eaten "as-is", with no additional processing (i.e. cooking) to remove it.

RTE foods include:
- Sliced fruit
- Deli sandwiches
- Fresh pressed juice
- Bakery items

Food Contact Surfaces
In addition to worrying about the food, you must also protect any surface which will come into direct contact with the food item.
- Special care must be taken to ensure these surfaces are properly cleaned and sanitized before, during, and after use.

Food contact surfaces can can include:
- Cutting boards or tables
- Deli slicer head
- Utensils (knives, spatulas, tongs, etc.)
- Worker’s hands

Regulations
There are many agencies that oversee food in the United States.
- FDA – Oversees food production outside of meat, poultry and eggs; also writes the Food Code.
- USDA – Oversees slaughter and processing of meat, poultry and egg products.
- CDC – Investigates and reports foodborne illness outbreaks.
- State and local agencies – Have jurisdiction over local food establishments.

The FDA Food Code
- The FDA Food Code is a set of guidelines produced by federal scientists and regulators to regulate food safety in the food retail industry.
- It is the decision of each local and state jurisdiction to adopt the FDA Food Code in part, in whole, or develop their own standards.
- Many current policies and regulations for sale of foods at farmers’ markets are based on the rules and guidelines of the FDA Food Code.

PDA and Local Health Departments
In Pennsylvania, oversight of food establishments falls to either the local health authority or to the Pennsylvania Department of Agriculture (PDA).
- Pennsylvania follows the Food Code for retail food establishments.
- PA Act 106 (2010) established:
  - Retail Food Facility Safety Act (3 PA.C.S.A. §§ 5701 – 5714)
  - Food Safety Act (Chapter 57 of PA Code 3)
Farmers' market vendors are considered Retail Food Establishments in Pennsylvania.

- License is required if selling unpackaged potentially hazardous foods or serving ready-to-eat foods.
- Are required to have completed a Certified Food Safety Manager course.

Exempt from licensing:
- Raw agricultural commodities / whole, uncut fresh fruits and vegetables.
- Prepackaged food that is not TCS.
- Offering certain free food samples (may be exempt).

Raw agricultural products are exempt from licensing fees but still must comply with food safety requirements and inspections.

Pre-packaged non-potentially hazardous foods are also exempt but need to fill out a Retail Food Plan.

A Retail Plan Review is a document that provides details on the food production operation and the products being sold.

- Required in PA if selling any foods other than raw agricultural commodities.

Farmers market vendors may be required to register as a food establishment.

- The location/facility where they are processing or storing food that they sell at the farmers market.
- This facility would need to be inspected and licensed.
- If they are processing at home or a residential kitchen, then this is considered a Limited Food Establishment.
- There is an application that explains the types of products that can be made.
- Foods are limited to non-TCS foods.

Example
- If a farmer/vendor is selling heads of lettuce, then no license is required.
- If he/she decides to sell a value-added product through washing, chopping, and bagging the lettuce, then the vending stand where the lettuce is sold would be considered a retail food establishment.
- The location where the lettuce was washed, chopped and bagged would be considered a food establishment, which must be licensed and inspected.
Chapter 1 - Understanding the risks

Questions?
Chapter 2: Food Safety Concepts

Slide 1-2

FOOD SAFETY CONCEPTS
CONTROLLING RISK FROM FARM TO FORK

Key Concepts to Keep Foods Safe
• Controlling time and temperature
• Preventing cross contamination
• Cleaning and sanitizing food contact surfaces
• Practicing proper personal hygiene

Slide 3-4

Controlling Time and Temperature
Temperature control is important for controlling microbial pathogens on TCS foods.
• Keeping foods out of the temperature danger zone prevents organisms from growing in food.
  Temperature danger zone (TDZ) (41°F to 135°F)

Controlling Time and Temperature
Cooking foods is the primary way for destroying microbial pathogens present on foods.
• Foods like raw meat must be cooked until they reach a specific temperature to kill bacterial such as Salmonella or E. coli.

Slide 5-6

Controlling Time and Temperature
Chilling foods is important to keep cooked TCS foods out of the TDZ.
• Cooked foods must be cooled quickly.
• Spore forming pathogens such as Clostridium perfringens can survive cooking and grow in foods which are not kept out of the TDZ.

Controlling Time and Temperature
Keep foods out of the TDZ as much as possible during handling, preparation, and serving.
• Foods which will be held hot must be served or stored at temperatures above 135°F.
• Foods which will be held cold must be served or stored at temperatures 41°F or below.
Controlling Time and Temperature

Using a thermometer is the only way to ensure proper time-temperature control.

- Types of thermometers:
  - Bimetallic
  - Digital (thermocouples, thermistors)
- Choosing the right thermometer and/or probe depends on what it will be used for.

Calibration of a thermometer is important to maintain the accuracy within (+/- 2°F).

- Bimetallic thermometers require regular calibration using:
  - Ice point calibration
  - Boiling point calibration
- Digital thermometers are not normally calibrated, although internal calibration should be verified.

Preventing Cross Contamination

Cross contamination is the transfer of hazards (biological, chemical, physical) from a contaminated source to a food or food contact surface.

- It can happen during food preparation or at the farmers’ market, but especially a concern when working with TCS and RTE foods.
Preventing Cross Contamination

Procedures for preventing cross contamination include:

- Store raw and RTE foods separately.
- Use separate equipment for raw and RTE foods.
- Separate the times working with raw and RTE foods.
- Use prepared food and ingredients.
- Clean and sanitize.

Examples of using separate equipment for raw and RTE foods can include:

- Using color coded cutting boards designated for raw foods (i.e. meat), and RTE foods (i.e. breads).
- Use separate utensils (i.e. knives) for handling raw foods and RTE foods.

Examples of using prepared food and ingredients can include:

- Using fully cooked meat as a pizza topping instead of raw meat.
- Using pasteurized egg yolks or whites.

Allergens are a special concern if they are transferred to a food which does not declare that allergen on its label.

Cross contact is the unwanted transfer of allergens into foods.

Cleaning and sanitizing is the primary way to prevent cross contact.

Allergens must be declared on label.

Sanitation has two primary components:

- Cleaning is the removal of food debris from a surface.
- Sanitizing is the act of reducing harmful microbial pathogens to safe levels.
Cleaning and Sanitizing Food Contact Surfaces

Food contact surfaces in particular, must be properly cleaned and sanitized:

• After they are used.
• Before beginning a new task.
• After a prolonged break.
• After a 4-hour period of production (unless processing in a refrigerated room).

Soaps and detergents are cleaning chemicals used to remove dirt and debris.

• Each type of cleaner works best under different conditions (grease, dirt, oils, etc.)
• Ensure the cleaner is EPA and FDA approved for use on food contact surfaces.

Rinsing with potable water ensures that any residual detergent on the surface is washed away.

• Residual detergent can inactivate the sanitizer.

Sanitizers are chemicals which kill or inactivate microorganisms.

• Sanitizers generally used in food production:
  • Chlorine-based
  • Quaternary ammonium (Quat)
  • Hot water (171°F or greater)
• It is important to follow the manufacturer’s instructions for temperature, concentration, and contact time.

Air drying allows surfaces to dry, wiping them down may re-contaminate the surface.

Practicing proper personal hygiene

People working with food can be a source of contamination.

• Practicing personal hygiene should include:
  • Developing and following a personal hygiene program.
  • Using proper handwashing and glove use.
  • Keeping good personal cleanliness.
  • Monitoring the health of employees.
Practicing Proper Personal Hygiene

A good personal hygiene program is essential for preventing contamination from personnel.

- The facility should have a written program and personnel should be trained before they begin work and on an ongoing basis.

Handwashing is one of the most important personal hygiene practices in preventing contamination of food.

- To properly wash hands:
  - Rinse hands under warm running water.
  - Apply approved hand soap or detergent.
  - Scrub hands for 10 to 15 seconds, paying attention to cleaning between fingers and under fingernails.
  - Rinse hands.
  - Dry with a single use paper towel or hand dryer.

Handwashing should be performed any time they have become contaminated including:

- Using the restroom.
- After touching body parts, including hair and face.
- After coughing, sneezing, and eating.
- Handling money.
- Touching raw foods, especially raw meats, poultry or seafood.
- Touching animals.
- Touching any contaminated surface.
- After 4 hours of continuous use.

Hand antiseptics or hand sanitizers should not take the place of handwashing, but can be used in conjunction with proper handwashing.

Gloves must be worn any time when handling RTE foods.

- Gloves should be single use.
- Must be changed any time they become dirty, when changing tasks, or when they are ripped or torn.
- Hands must be washed before putting gloves on, and gloves must be put without contaminating them.

Personal cleanliness is key to preventing cross contamination from personnel.

Personnel working with food must:

- Wear clean clothing and bath regularly.
- Wear hair coverings when working with food.
- Not wear false fingernails, fingernail polish, hairclips, or hairpins.
- Not wear jewelry (a plain wedding band is allowed).
- Secure objects like pens and pencils from falling into food.
Practicing Proper Personal Hygiene

Health considerations – Certain foodborne illnesses can be transferred from a sick worker to the food or to a food contact surface.

- Personnel who have the symptoms of diarrhea or vomiting must be prevented from working with food.
- Any employee who shows jaundice (yellow skin and eyes) should remain away from the operation.
- Jaundice can be an indication of Hepatitis A.

Any personnel diagnosed with the following symptoms cannot return to work until they have been cleared by a medical professional:

- Salmonella Typhi
- Salmonella species other than Typhi
- STEC E. coli
- Shigella
- Hepatitis A (Showing signs of jaundice)
- Norovirus

What’s wrong with this picture?

What’s wrong with this picture?
What's wrong with this picture?
Chapter 3: Facilities, Equipment, Water, and Garbage Disposal

Slide 1-2

FACILITIES, EQUIPMENT, WATER, AND GARBAGE DISPOSAL

EQUIPPING FOOD SAFE FACILITIES

Impact of Facilities on Food Safety
The facilities (structure, walls, floors, equipment, utilities) at your food preparation facility can vary greatly and impact the safety of food products.

• Considerations must be made for the types of products being made:
  – Ready-to-eat and TCS foods will require a higher level of cleanliness compared to raw agricultural commodities.
  – Overcoming facility limitations doesn’t have to be difficult or expensive.

Slide 3-4

Maintaining Clean and Safe Facilities to Minimize Risk

• Facility Grounds and Exterior
  • Outdoor areas should be maintained to minimize dust and pest and to prevent standing water.
  • Asphalt or concrete are ideal.
  • Exterior walls should be weather resistant, free of holes and cracks.
  • Exterior openings should have doors and windows which are tight fitting and kept closed or screened

Facility Grounds and Exterior

• Outdoor areas should be maintained to minimize dust and pest and to prevent standing water.
  • Asphalt or concrete are ideal.
• Exterior walls should be weather resistant, free of holes and cracks.
• Exterior openings should have doors and windows which are tight fitting and kept closed or screened.

Slide 5-6

Facility Interior floors and walls

Interior floors and walls:
• Have surfaces that are easily cleanable.
• Be smooth and free of cracks and crevices.
• Be free of barriers from cleaning.
• Porous walls should be coated.
• Floor/wall junctions should be coved or sealed.
• No carpet in food preparation areas.

Facility Utilities

• Drains should be in places where wash-down procedures are used, and floors should be sloped.
• Light bulbs should be shielded, covered, or coated if located in food preparation areas.
• HVAC should be designed so intake and exhaust vents don’t lead to contamination.
### Slide 7-8

#### Facility Utilities

- **Eating and drinking areas** should be designated for employees to eat and drink away from food preparation and cleaning areas.

- **Pest control devices** should not be used or stored near food preparation areas.

- Animals must be excluded from operations.

#### Temporary Facilities

Temporary facilities should be sufficient to prevent food products from becoming contaminated.

- Floors can be concrete or asphalt, but if gravel or dirt, must be covered to control dust and standing water.

- The walls should protect the interior from weather, wind, dust, and debris.

- Studs, joists and rafters may be exposed, but not in permanent facilities.

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### Slide 9-10

#### Storage Areas

- **Food and ingredient storage areas** should be kept dry free of debris.

- Keep food items and food utensils stored at least 6 inches off the floor.

- **Cleaning chemicals** and **maintenance chemicals** should be stored in a separate location from food and ingredients.

#### Storage Areas

Never store food or ingredients in:

- Locker rooms
- Toilet rooms
- Garbage rooms
- Mechanical rooms
- Under unshielded sewer lines
- Under leaking water
- Under stairwells
- Under anything that can contaminate food

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### Slide 11-12

#### Food Processing Equipment

Food contact surfaces of equipment should be:

- Safe
- Durable
- Corrosion resistant
- Non-absorbent
- Easy to clean
- Free of cracks, chips, sharp angles, and rough welds or joints.

#### Food Processing Equipment

- Should be placed to facilitate cleaning around and under the equipment.

- **Floor mounted equipment** must have 6 in of clearance or be sealed to the floor.

- **Tabletop equipment** must have 4 in of clearance or sealed to the table.
Food Processing Equipment

- Equipment should be certified by an ANSI accredited certification program like NSF.
- Equipment and food contact surfaces should NOT be made of the following materials:
  - Cast iron
  - Lead
  - Copper and copper alloys
  - Galvanized metal
  - Sponges
  - Wood

Washing Equipment

- Automated washing equipment must be operated according to the manufacturer’s instructions.
- Ensure that the equipment is meeting the proper **temperature**, **pressure**, and **chemical concentration** parameters.

Washing Equipment

- Handwashing sinks should be equipped with:
  - Soap
  - Potable water (100°F)
  - Proper signage
  - Garbage receptacle
  - A way to dry hands (paper towels or hand drying device)

Washing Equipment

- Warewashing sinks or three compartment sinks are normally required for manual warewashing.
- The warewashing sink must be cleaned before use and throughout the day if used to wash wiping cloths, wash produce, or thaw food.

Washing Equipment

- Service sinks should be equipped with a floor drain and available for cleaning tools and disposal of mop water or liquid waste.

Water and Plumbing

- **Potability** is a term used to describe water which is suitable for human drinking.
- Water used in food processing operations must be potable and tested for potability if it is not from a municipal source (well-water).
- Contact your local water regulatory authority to determine water testing requirements.
### Water and Plumbing

- Plumbing systems must be made of approved materials and maintained in a manner that prevents contamination.
- Approved back flow or back-siphonage prevention devices should be installed in any location where there is a risk of a cross connection.
- A cross connection is the connection of potable water with a source of a non-potable or contaminated water.

### Trash Disposal

- Indoor trash containers should be leak proof, cleanable, covered, and cleaned regularly.
- Outdoor trash containers should be located on a concrete or asphalt surface, kept close, and drain plugs should be closed.
- Recyclables containers should be collected in an area that is away from food preparation and food storage areas.
Chapter 4: Sourcing and Purchasing

Slide 1-2

SOURCING AND PURCHASING
THE INGREDIENTS TO KEEP FOODS SAFE

Penn State Extension

Key Areas for Sourcing and Purchasing Ingredients and Goods
- Approved Suppliers
- GAPs, GMPs, and HACCP
- Inspection of Incoming Goods
- Supplier Recalls
- Selling Other Farmers’ Goods

Slide 3-4

Approved Suppliers
- Obtain ingredients and other food products from approved, licensed, inspected, and respectable suppliers.
- Using approved suppliers is a key component to managing food safety risks associated with the ingredients and packaging used to make products.

Approved Suppliers
- Grocery stores – In general, food products sold in a retail grocery store should come from inspected and approved suppliers.
- For less familiar brands or unbranded products, contact the supplier directly.

Slide 5-6

Approved Suppliers
- Ingredient suppliers – If choosing to buy direct from a producer (farmer), processor, or broker, more information will be needed:
  - Qualifications of the supplier.
  - Current and past inspection results and reports.
  - Record of the suppliers contact information.
  - Determination of how products are labeled, coded, and tracked.
  - Notification process for supplier recall.

Approved Suppliers
- Good Agricultural Practices (GAPs) are practices, measures, and standards which farmers can follow to reduce food safety risks throughout planting, growing, harvesting, and post-harvest operations.
- If sourcing ingredients direct from a farmer, it is important to know if they are using GAPs.
Approved Suppliers

How to discuss GAPs with a farmer and potential supplier:

- Does the farmer follow GAPs, and do they have written procedures and plans which you can view?
- Discuss the use of manure as a fertilizer, irrigation, pesticide use, farm and wild animal separation, and post-harvest procedures for packing, washing, storage, and shipment.
- Has the farm passed a voluntary GAP audit, and can you view the results?

Good Manufacturing Practices (GMPs) are a set of rules, guidelines, and practices that are followed by food production facilities.

- Help minimize food safety risks and maintain quality.
- Cover areas such as personnel hygiene, employee training, allergen controls, pathogen control, record keeping, sanitation operations.

Approved Suppliers

- Approved suppliers should follow GMPs and have them incorporated into their food safety plans and procedures.
- Inspection reports should provide evidence that those procedures are followed and completed and can be requested as part of an approval process.

Hazard Analysis and Critical Control Points (HACCP) is a risk-based management system used to reduce and control food safety hazards during food production.

- In the U.S., the use of a HACCP system is required to produce meat, poultry, and egg products under USDA inspection, and juice and seafood under FDA inspection.
- Future food safety regulations will require all FDA regulated food facilities to utilize HACCP.
- Food Safety Modernization Act (FSMA)

Approved Suppliers

- Hazard Analysis and Critical Control Points (HACCP) is a risk-based management system used to reduce and control food safety hazards during food production.
- In the U.S., the use of a HACCP system is required to produce meat, poultry, and egg products under USDA inspection, and juice and seafood under FDA inspection.

Inspection of Incoming Goods

Incoming raw goods should be inspected.

- Have designated personnel inspect incoming goods.
- Hold incoming shipments in a separate area until they have been determined to be safe and suitable for storage and use.
Inspection of Incoming Goods

Check the following during your incoming goods inspection:

- Delivery vehicle status
- Correct material
- Package code and expiration dating
- Packaging integrity
- Product integrity
- Signs of pests

For TCS items:

- Verify fresh foods are received below 41°F and frozen foods are frozen with no signs of thaw.
- Store temperature sensitive food products immediately.
- Do not accept the shipment if the temperature is not in the correct range and contact the supplier immediately.
- For store purchases, transport refrigerated and frozen products in a cooler with ice or in another type of refrigerated storage device.

To verify the temperature of the shipment:

- Randomly choose several items and insert the thermometer into the thickest portion of the product.
- Packaged product can be opened or for reduced oxygen packaging (ROP), wrap the package around the stem of the thermometer.
Chapter 5: Product Handling and Preparation

Slides 1-2

PRODUCT HANDLING AND PREPARATION
PUTTING FOOD SAFETY CONCEPTS TO PRACTICE

Key Areas for Product Handling and Preparation
- Food preparation and processing
- Washing
- Mixing, Blending, and Grinding
- Cooking, Chilling, and Thawing
- Packaging
- Labeling
- Transportation
- Point of Sale Preparation

Slides 3-4

Regulatory Considerations
When preparing food, specific regulatory licensing requirements may apply.
- Retail food establishment
- Food Establishment
- Limited Food Establishment

Food Preparation and Processing
- The processing of food can range from activities as simple as washing to more complicated procedures like heating and packaging.
- Food preparation and processing must occur under sanitary conditions and food safety hazards must be controlled.

Slides 5-6

Washing
Washing systems are important for cleaning food items for sale (i.e. produce) as well as further processing.
- Water must be maintained so it does not become a source of contamination.
- Separate washing areas from other processing areas such as final product storage and packaging.

Washing: Fruits and Vegetables
Washing fresh fruits and vegetables is considered a processing step (FDA Food Code).
- Washed fruits and vegetables are required to be handled as a RTE food item.
- Un-washed fruits and vegetables are not viewed as RTE foods since it is assumed the consumer would perform the tasks of washing, peeling, hulling or shelling before consuming the product.
Washing: Fruits and Vegetables

- Produce can be washed with water, the water temperature should be warmer than the produce.
- If chemicals are added for washing, sanitizing, or peeling, they must be approved for use and must be used according to manufacturer’s instructions.

Sanitizing Wash or Rinse for Poultry

- The use of a sanitizing rinse, dip, or spray during poultry slaughter and processing can increase the safety of that product.
- Many organic and natural sanitizers can be used prior to packaging such as lactic acid, hydrogen peroxide, and peracetic acid.
- Applying sanitizers to whole poultry or parts can be simple and affordable.

Cooking

Understanding proper cooking temperatures is key to ensuring safe cooked foods.
- Taking the temperature of cooked food is the only scientifically validated way to determine if food is safe (and never by color change, touch, or taste).
- Cooking during the processing of RTE foods must follow FDA Food Code (3-401.11) or applicable regulations.
- Note that Food Code temperatures are different than Consumer recommended temperatures.
Slides 13-14

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Food</th>
<th>Temperature (°F)</th>
<th>Rest Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground Meat &amp; Meat Mixtures</strong></td>
<td>Beef, Pork, Veal, Lamb</td>
<td>155</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Turkey, Chicken</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td><strong>Fresh Beef, Veal, Lamb</strong></td>
<td>Steaks, roasts, chops</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>Chicken &amp; Turkey, whole</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Poultry breasts, roasts</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Poultry thighs, legs, wings</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Duck &amp; Goose</td>
<td>165</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Stuffing (cooked alone or in bird)</td>
<td>165</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Food</th>
<th>Temperature (°F)</th>
<th>Rest Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pork and Ham</strong></td>
<td>Fresh pork</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>Fresh ham (raw)</td>
<td>145</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>Precooked ham (to reheat)</td>
<td>135</td>
<td>None</td>
</tr>
<tr>
<td><strong>Eggs &amp; Egg Dishes</strong></td>
<td>Eggs</td>
<td>Cook until yolk and white are firm</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Egg dishes</td>
<td>155</td>
<td>None</td>
</tr>
<tr>
<td><strong>Leftovers &amp; Casseroles</strong></td>
<td>Leftovers</td>
<td>165</td>
<td>None</td>
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<tr>
<td></td>
<td>Casseroles</td>
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Slides 15-16

<table>
<thead>
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<th>Food Category</th>
<th>Food</th>
<th>Temperature (°F)</th>
<th>Rest Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seafood</strong></td>
<td>Fin Fish</td>
<td>145 or cook until flesh is opaque and separates easily with a fork.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Shrimp, lobster, and crabs</td>
<td>Cook until flesh is pearly and opaque.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Clams, oysters, and mussels</td>
<td>Cook until shells open during cooking.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Scallops</td>
<td>Cook until flesh is milky white or opaque and firm.</td>
<td>None</td>
</tr>
<tr>
<td><strong>Chilling</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chilling cooked foods rapidly is important and can be accomplished by:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Placing foods in shallow pans.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Separating food into smaller portions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Using rapid cooling equipment.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Stirring food in a container in an ice water bath.</td>
<td></td>
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<tr>
<td></td>
<td>• Using heat transferring containers.</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>• Adding ice to the food as an ingredient.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thawing</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Proper thawing is important to keep foods out of the TDZ before cooking or further preparation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Thaw at refrigeration temperatures.</td>
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<tr>
<td></td>
<td>• Thaw under cool running water (less than 70°F).</td>
<td></td>
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<tr>
<td></td>
<td>• Thaw in a microwave, but must cook immediately.</td>
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</tr>
<tr>
<td></td>
<td>• Thaw as part of the cooking process.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Open frozen fish packaged in ROP packaging during thawing.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Packaging
Packaging of food products protects food from contamination and intentional tampering, while providing a surface for required labeling.

Commonly used packaging methods:
- Canning (hermetically sealed)
- Vacuum Packaging
- Re-sealable storage bags and containers
- Other pre-packaging

Packaging: Canning
Whether in glass or metal cans, canned foods can provide long-term stability of food products.

Regulatory restrictions are in place for the following:
- Low acid canned foods are foods with a finished equilibrium pH greater than 4.6 and water activity greater than 0.85.
- Acidified foods are low-acid foods which acids or acid foods are added with a finished equilibrium pH of 4.6 or below and water activity greater than 0.85.

Packaging: Vacuum Packaging
Vacuum packaging machines remove air from a bag or container and create a seal to restrict air and moisture.

- While there is an advantage of increase shelf-life there are restrictions because certain products can be a Clostridium botulinum risk.

Labeling
- Food labels are important and necessary to provide ingredient and nutritional information.
- Foods which fall under USDA or FDA inspection will have different but similar labeling requirements.
- At a minimum, provide the processor’s contact information, ingredient listing, and allergens declaration (See 21 CFR part 101).
- Refer to chapter 5 for guidance on specific foods.

Transportation
- Clean and sanitize transport surfaces.
- Use secondary containers
- Monitor temperatures of food in containers
- Bring extra ice or cooling and hot holding equipment.
- Keep raw, RTE, and TCS foods separate.
Point-of-Sale Preparation

Challenges:

• Un-cleanable or difficult to clean surfaces.
• Lack of washing facilities.
• Lack of electrical power.
• Lack of proper refrigeration or frozen storage equipment.
Chapter 6: On-site Handling, Service, and Sales

Slides 1-2

Key Areas for On-site Handling, Service, and Sales
- Maintaining sanitary conditions at the farmers’ market
- Food product display
- Packaging at the market
- Food samples
- Handling money
- Customer interaction

Slides 3-4

Maintaining Sanitary Conditions at the Farmers’ Market
- Farmers’ market operations present some of the biggest food safety challenges.
- Taking the time to plan and prepare a point-of-sale food safety plan can ensure a safe and profitable experience.

Slides 5-6

Maintaining Sanitary Conditions at the Farmers’ Market
- Put food safety concepts into practice at the farmers’ market:
  - Follow a developed cleaning and sanitizing plan (set-up, breakdown, routine cleaning, handling spills).
  - Ensure personnel are trained or understand the food safety practices and procedures used at the market.
  - Monitor employee hygiene and cleaning and sanitizing practices throughout the market day.

Maintaining Sanitary Conditions at the Farmers’ Market
- If a warewashing sink is not provided at the farmers’ market, one can be easily assembled using affordable materials.
  - Three large buckets
  - Potable water
  - Soap and sanitizer
  - Cleaning tools
  - Drying rack
Maintaining Sanitary Conditions at the Farmers’ Market

How to use a temporary warewashing sink:
• Fill the first bucket with soapy water for **washing**.
• The second bucket is filled with fresh water for **rinsing**.
• The third bucket is filled with sanitizer solution for **sanitizing**.
• Set up a **drying** rack on a clean and sanitized surface or hand-dry items with disposable towels.
• Locate your warewashing sink away from the sales and food vending areas
• Use a municipal sewer or established draining areas for disposing of waste water.

A handwashing station is an important tool to help reduce food safety risks at the farmers’ market.
• A handwashing station will be necessary if handling or preparing raw foods, with the exception of pre-packaged foods and raw agricultural commodities (i.e. produce from the field).
• Certain municipalities may require handwashing stations for both vendors and customers, depending on the types of food sold.

Temporary handwashing stations can be purchased or easily constructed with affordable materials.

Setting up and using a temporary handwashing station at the farmers’ market:
• Bring extra water, soap, and paper towels.
• Monitor the handwashing station to ensure water, soap, and paper towels are available.
• Remove waste water frequently into a public sewer system or approved drainage area.
• Access to handwashing station for customers should be considered.

Displaying and presenting food at the farmers’ market can present food safety challenges.
Keep foods displayed for sale safe and sanitary:
• Use “display foods” keep for-sale items in a clean and sanitized storage container.
• Do not place un-packaged foods directly onto a vending table without a covering, use secondary coverings or containers.
• Prevent customers from touching un-packaged foods by covering them with clear coverings (i.e. cellophane wrap).

The vending table should be made of materials which can be cleaned and sanitized before setting up food displays.
• Wood stands are not easily cleaned and sanitized, so alternatives may be needed.

Food Product Display

Packaging at the Market

Reduce the risk associated with selling un-packaged foods at the farmers’ market:
• Place un-packaged TCS and RTE foods on clean and sanitized surfaces.
• Prevent customers from touching un-packaged TCS and RTE foods. Provide utensils or sanitary tissues for handling un-packaged foods.
• If providing bags for customers, use only new and sturdy bags, capable of holding the weight of the food items.

Packaging at the Market

Reduce the risk associated with selling un-packaged foods at the farmers’ market:
• Provide customers with safe transport and storage guidelines for the specific foods they purchased (i.e. separate raw meat and produce, keep raw chicken below 41°F).
Prevent or minimize the risk of bare hand contact during packaging.

Packaging at the Market
• Procedures used for packaging food should minimize the risk of contamination.
• Handwashing and/or the use of disposable gloves can minimize the risks of bare hand contact of food.

Minimizing bare hand contact can be achieved through these other strategies:
• Use the “inside-outside bag technique”.
• Use produce bags, butcher paper, tissue paper, plastic wrap, foil, baking sheet or other wrapping material used in food preparation to grab, handle, and wrap foods without touching them.

Serving food samples can be an effective way to attract customers and increasing sales, however:
• Depending on the types of food products served, specific risks and requirements must be considered.
• Check with the local/state sanitarian and your market manager before preparing and serving samples.

Preparing food samples before arriving at the farmers’ market:
• Follow food safety preparation procedures specific for that food product.
• Keep food samples covered, stored, and transported in a sanitary manner.
• Keep cold food samples cold and hot food samples hot during storage and transport.

Preparing food samples at the farmers’ market:
• Clean and sanitize all surfaces before preparing food samples. Use secondary surfaces (i.e. cutting boards).
• Wash hands before handling and preparing food samples. Hand sanitizers alone are not sufficient. Continue to wash hands and/or change gloves periodically or when contaminated.
• Ensure all utensils, kitchenware, and equipment are cleaned and sanitized before food sample preparation and periodically (every 4 hours) throughout the day.
While serving food samples at the market, continue to ensure food samples are handled in a sanitary manner.

Serving food samples at the farmers’ market:
- Serving customers individually ensures proper handling.
- Servers should wear disposable gloves properly and/or wash hands before handling food samples, and re-wash as necessary.
- Use clean and sanitized utensils to handle food samples for customers.

Self-served food samples:
- If food samples are self-served, ensure they are placed onto clean and sanitized trays, plates, bowls or individual serving cups.
- Provide toothpicks, tongs, or disposable utensils for customers.
- Keep TCS food samples on ice or in a device capable of keeping the product cold.
- Throw away any un-eaten samples at the end of the day, do not re-serve samples.

Paper money, coins, and plastic credit cards can be sources of potentially harmful bacteria and viruses.

Food handlers must make certain precautions when handling both money and working with food.

Cash registers, credit card machines, smart-phones, and tablets can also be sources of harmful bacteria and viruses.

If food is pre-packaged there is no concern for contamination from money.

Providing customers with receipts is an important business practice and can be critical during a foodborne illness outbreak or recall.

The receipt also provides customers with business contact information in case of complaints or issues.
Customer Interaction

- Vendors may experience busy hours or become overwhelmed with customers at certain times.
- The risk of foodborne illness increases when it is easy for mistakes to be made.

Maintain food safety and manage heavy customer traffic:

- Pre-packaging foods can eliminate the need for further packaging at the market and save time during peak hours.
- Add additional employees during peak hours.
- Designate employees to perform specific tasks.
- Segregate food product selection and money transaction areas of your food stand.
- Schedule break times so workers are available for peak hours.
PROCEDURES AND RECORDS, TRACEABILITY, AND LIABILITY

PROTECTING YOUR BUSINESS

Key Areas for Procedures, Records, Traceability, and Liability

• Procedures and Records
• Traceability
• Recalls
• Liability and Insurance

PROCEDURES AND RECORDS

• Procedures – Developing, writing, and following dedicated procedures for the preparation and processing of food is key to sustaining a safe and successful food business.

Consider developing and following dedicated procedures:

• Ensures food safety practices aren’t forgotten.
• Helps to maintain consistency of food products.
• Provides regulators with the information they need to inspect and regulate your operations.
• Can be used to train other personnel or new employees.

Procedures can be developed for numerous processes and applications:

• Preparation of specific food products.
• Cleaning and sanitizing programs.
• Personal hygiene programs.
• Produce harvesting and packing
• Post-harvest washing or culling
• Farmers’ market set-up/break-down
• Facility and equipment maintenance

Records – Keeping records associated with the procedures in place ensures food safety practices are being followed.
**Procedures and Records**

Consider keeping and maintaining records for specific procedures in place:

- Provides proof that a particular task was completed.
- Ensures food safety practices were performed within acceptable limits (i.e. temperature, concentration).
- Demonstrates to regulators that procedures are being followed and taken seriously.
- Can provide critical information needed during recalls and outbreaks.

**Traceability**

- **Traceback** or **traceability** is the ability to track food products through the supply chain and back to their originating sources (i.e. growers, packers).
- Traceback systems won’t prevent foodborne illness, but will provide the ability to rapidly identify the source of a contaminated food.

**Recalls**

A **food recall** is a system or the action of removing food products from sale and distribution that are in violation of the law or pose a public health risk.

- Food recalls can be initiated for many reasons:
  - Positive tests for pathogens
  - Undeclared food allergens
  - An outbreak associated with a specific food or ingredient
  - Other hazards associated with a food product.

**Recall management plan** can help guide processors through the rigors of a recall, and allow for important information to be rapidly distributed to public health officials.
Recalls
It is important to monitor FDA and USDA recall announcements if using commercially obtained ingredients.


In case of a recall or outbreak associated with an ingredient used in your food product:

- Follow the federal or manufacturer’s recommended actions listed on the recall announcement.
- Remove those items from the preparation area, and label them to ensure they are not used for further processing.
- Implement a recall plan if the recalled ingredient was used in a food product you produced and/or sold.

Recalls
During a recall of your products, public health agencies will likely require specific information:

- Identity of the food product involved in the recall.
- Reason for the removal or correction and the date and circumstances under which the food product deficiency or possible deficiency was discovered.
- Evaluation of the risk associated with the deficiency or possible deficiency.
- Total amount of such food products produced and/or the time span of the food production.

- Total amount of products estimated sold or distributed.
- Distribution information, including the number and locations of sales, and any information on customers who purchased the food item.
- A copy of a recall announcement, if any has been issued, or a proposed communication if none has been issued.
- Proposed strategy for conducting the recall.
- Name and telephone number of the designated food establishment representative.

Insurance and Liability
Although few cases of outbreaks, consumer injury, or other legal cases have affected farmers’ markets in the U.S., it is becoming apparent that farmers and vendors may be vulnerable without the necessary insurance.

- Farm liability insurance may not cover incidents occurring at the farmers’ market or injury or illness associated with “on-farm” sales.
- Obtaining additional liability insurance is an important option to consider as a retailer of food for the public.
Curriculum vitae – Joshua A. Scheinberg

Education
Ph.D. Food Science, Pennsylvania State University, May 2016.
M.S. Food Science, Pennsylvania State University, August 2012.
B.S. Major: Biology; Minor: Leadership, Virginia Polytechnic Institute and State University, May 2006

Publications
Peer Reviewed (in reverse chronological order)


External Funding Summary
Secured $20,000 in funding from the Pennsylvania Department of Agriculture, Food Safety Resource Center as Project Leader for the study, “A microbiological quality assessment of produce and meat products sold at farmers’ markets in Pennsylvania.”

Select Honors and Awards (in reverse chronological order)
- Penn State Evans Family Award for Graduate Student Extension Achievement (2015)
- Penn State College of Agricultural Sciences Emerging Leader Endowment Scholarship and Program Recipient (2014)
- Institute of Food Technologists Food Microbiology Division Poster Competition, First Place (2014)
- Willliam B. Rosskam Memorial Scholarship, Penn State (2013)
- Penn State Food Industry Group Graduate Student Leadership Award, Penn State (2013)
- Robert D. and Jeanne L. McCarthy Memorial Graduate Scholarship, Penn State (2012)
- Earl and Veronica Casida Graduate Fellowship in Microbial Food Safety. Penn State (2011-2014)