Microbiological quality and safety of fresh produce in West Virginia and Kentucky farmers’ markets and validation of a post-harvest washing practice with antimicrobials to inactivate *Salmonella* and *Listeria monocytogenes*

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**A B S T R A C T**

This study aimed to evaluate the microbiological quality/safety of fresh produce from farmers’ markets (FM) and assess the post-harvest washing practice with antimicrobials to inactivate *Salmonella* and *Listeria monocytogenes* on fresh produce. In study I, 212 produce samples were tested for the presence of *Salmonella* and *Listeria* spp. using modified FDA-BAM methods. Aerobic plate counts (APCs), total coliforms (TCCs), and yeast/molds were analyzed on petri-films. Among the 212 samples, the APCs, TCCs, and yeast/molds were 3.72 e 5.63, 3.67 e 5.47, and 3.07 e 4.13 log CFU/g, respectively, with spinach containing the highest (*P* < 0.05) populations. Among all tested samples, *Salmonella enterica* was detected on 18.6% of spinach, 10.9% of tomatoes, 18.5% of peppers, and 56.3% of cantaloupes, which is much higher than previous reported. Only 3.78% of the samples were confirmed for *Listeria* spp., and 50% of them were identified as *L. monocytogenes*, based on multiplex PCR results. Due to the high percentage of pathogens detected on the farmers marker produce an evaluation of post-harvest produce washing with various antimicrobials was conducted in study II. Specifically, spinach, tomatoes, green peppers and cucumbers were inoculated with *S. Typhimurium* and Tennessee *L. monocytogenes* and washed in tap water, vinegar water (10%), lactic acid (5%), a lactic and citric acid blend (2.5%), and sodium hypochlorite (200 ppm) for 30 s or unwashed. Vinegar water (10%) showed better (*P* < 0.05) reduction of *S. Typhimurium* and Tennessee on tomatoes and cucumbers, and *L. monocytogenes* on tomatoes and peppers than tap water. The three antimicrobials reached an additional reduction level of 0.9 e 2.7 (*S. Typhimu-rium and Tennessee*) and 0.2 to 1.4 log CFU/g (*L. monocytogenes*) compared to tap water. Lactic acid indicated the best (*P* < 0.05) reduction of *S. Typhimurium* and Tennessee on tomatoes and green peppers, and sodium hypochlorite showed the best (*P < 0.05*) reduction of *L. monocytogenes* on cucumbers. The results supplied important information for FM vendors to develop post-harvest protocols to control foodborne pathogens.

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1. **Introduction**

The consumption of fresh produce in the U.S. increased significantly from 154.4 to 186 pounds (per capita availability) from 1970 to 2014 (USDA-ERS, 2016). Fresh produce comes from multiple sources and is often eaten without cooking. Therefore, it is susceptible to foodborne pathogen contamination and must be handled carefully from the farm to the table, to ensure that there is no contamination of the produce from the farmer, shipper, processor, foodservice operators, retailers or consumers. Unfortunately, in the US there were approximately 131 outbreaks...
associated with 20 different fresh produce commodities from 1996 to 2010, resulting in 14,350 illnesses, 1382 hospitalizations and 34 deaths (U.S.-FDA, 2016a).

In the past 20 years, there has been an increasing demand for "locally grown" food in the United States (Scheinberg, Doores, & Cutter, 2013). The surge of demand for locally produced food has created jobs and opportunities for small agriculture businesses throughout the nation. Therefore, farmers’ markets, roadside stands, pick-your-own farms, and community-supported agriculture are increasing in popularity. According to the United States Department of Agriculture (USDA) Economic Research Service (ERS), the number of farmers’ markets in the USDA National Farmers Market Directory has more than quadrupled since 1994. Nearly 8700 farmers’ markets operated in 2016, up from 6100 in 2010, and 1800 markets in 1994 (USDA-ERS, 2017). The USDA estimated that the total domestic locally produced food sales reached at least $12 billion in 2014, and it is estimated to achieve the $20 billion target by 2019 (USDA, 2016). Undoubtedly, fresh produce sales dominate the farmers’ market landscape, and shopping at a farmers’ market is a convenient and economical way to obtain locally grown fresh fruit and vegetables for families.

As the farmers’ markets have become more popular, there has been increasing concern regarding the microbial safety of the available produce. In 2008, Campylobacter contamination in raw bagged peas caused 18 people to become ill at five south-central Alaska farmers’ markets (Gardner et al., 2011). In 2011, strawberries contaminated with Escherichia coli O157:H7 and sold at a farmers’ market in Oregon sickened 16 people and caused 1 death (Food Safety News, 2011). A recent study in 2014 reported that one Salmonella spp. was confirmed on fresh herbs sampling from 13 farmers’ market in the west coast of the U.S. (Levy et al., 2014). In 2015, an E. coli O157:H7 outbreak linked to a food truck serving several farmers’ markets in Seattle, WA, resulted 6 illness and 3 hospitalization (Food Safety News, 2015).

Farmers’ markets are a very important agriculture business in West Virginia, creating an average annual revenue of $41,200 for full time produce farmers and approximately $20,000 for part time farmers (internal unpublished data). Morgantown, the second largest city in WV, has 6 farmers’ markets opening from Monday to Saturday. The Morgantown, WV farmers’ markets each contain 5 to 35 vendors with half of their total gross sales generated from vegetables and fruits. In Kentucky, there are more than 159 farmers’ markets across the state (Kentucky Department of Agriculture, 2016). Bowling Green, the third largest city in KY, has three farmers’ markets opening Tuesday and Saturday. The Bowling Green, KY markets have approximately 100 vendors with 45% of them selling fresh produce. Our recent Good Agriculture Practices (GAP) survey of 160 small-scale produce growers in 21 counties across KY indicated that 90% familiar with GAPs, but only 47% opted to practice water quality GAPs and only 55% choose to observe soil amendment GAPs. Participants also failed to identify many sources of potential microbiological contamination including soil, ice, and cooling and refrigeration (only 28–41% recognition, Vincent et al., 2015). Therefore to protect the produce in farmers’ markets from food safety risks, it is important to assess and understand the risks of foodborne pathogen contamination during vendor produce handling. Further, no information is currently available regarding the presence of pathogens on produce that is sold at WV and KY farmers’ markets.

The new Food Safety Modernization Act (FSMA)-Produce Safety Rule was proposed in 2013 and became effective in 2015 to improve fresh produce safety nationwide (U.S.-FDA, 2015). Small produce farms are exempted from the FSMA if the farms 1) sold ≤$25,000 average annual produce during the previous three-year period; 2) average <$500,000 in food sales annually (for the last 3 years); and 3) sell most of their food directly to consumers, restaurants and stores within the state or 275 miles or less from the farm (U.S.-FDA, 2015). However, a farm with a qualified FSMA exemption is still required to have their information (name, address, place of produce grown) on the label of their produce. Although FSMA allows flexibility for local small produce growers the exemption can be withdrawn if their products has food safety problem or their farm directly linked to an outbreak as determined by FDA (U.S.-FDA, 2015).

Post-harvest produce pathogen control processes are important for small produce growers to reduce pathogens on produce surfaces. The WV Small Farm Center and WV Farmers’ Market Association organized two short courses on post-harvest produce safety for small growers from 2015 to 2016 (Shen, 2015, 2016a). The short course attendants, especially local farmers’ market managers, were very interested to know the antimicrobial efficacy of commercial antimicrobial chemicals on produce surfaces, such as vinegar water. The “three-step” washing process (water, water, followed by antimicrobial application) has been suggested to be effective for removal of pathogens from food surfaces to improve on-farm food safety (Strohbehn et al., 2013). The WV Small Farm Center is also encouraging local small produce growers to apply the “three-step” washing procedure to produce surfaces if their produce are eaten raw or are grown close to the ground (personal communication with Dr. Tom McConnell, Program Leader of the WV Small Farm Center). The effectiveness of antimicrobial chemicals such as chlorine, peracetic acid, lactic acid, acetic acid, citric acid, chlorine dioxide, and ozone has been documented in the new guidelines of United Fresh Produce Association (Gombas et al., 2017) for industry scale fresh cut produce processors. However, the efficacy of these antimicrobials to reduce the foodborne pathogen risk has not been validated on locally grown fresh produce.

Therefore, the objective of this study was to 1) evaluate the prevalence of Salmonella enterica spp. enterica and Listeria spp. as well as the populations of aerobic plate counts (APCs), coliforms and yeast/molds on fresh produce obtained from farmers’ markets in Morgantown, WV and Bowling Green, KY; and 2) assess post-harvest washing practices with antimicrobials to control S. Typhimurium and Tennessee and L. monocytogenes on fresh produce from farmers’ markets.

2. Materials and methods

2.1. Fresh produce sample collection and preparation

Based on project budgets, the experimental protocol called for approximately 200 samples of 4 or 5 fresh produce commodities from at least 5 vendors of each commodity. In total 212 fresh produce samples of tomato (64 samples, 13 vendors, 4–6 each), green pepper (54 samples, 11 vendors, 4–6 each), cucumber (35 samples, 5 vendors, 6–8 each), cantaloupe (16 samples, 12 from one vendor, 4 from the other vendor) and spinach (43 samples, 8 vendors, 5–7 each). Samples were aseptically collected from a total of 39 vendors from two farmers’ markets in Morgantown, West Virginia, and one farmers’ market in Bowling Green, Kentucky. Tomato, green pepper, cucumber and spinach are the four most popular produce commodities in farmers’ market in the fall. Cantaloupes were also collected due to the recent 2011 L. monocytogenes outbreak (CDC, 2011), although only one vendor was selling this commodity in each city.

Morgantown is the second largest city in WV and the location of West Virginia University (WVU), their sample collection was coordinated with the Morgantown Farmers’ Market Association and WV Small Farm Center. Bowling Green is the third largest city in KY and the location of Western Kentucky University (WKU, our
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متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
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دانلود فوری مقاله پس از پرداخت آنلاین
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