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A three-year survey of Florida packinghouses to determine microbial loads on pre- and post-processed tomatoes

J. De [a], Y. Li [a, 1], A. Sreedharan [a], R. Goodrich Schneider [a], A. Gutierrez [a], M. Jubair [a], M.D. Danyluk [a, b], K.R. Schneider [a, *]

[a] Food Science and Human Nutrition Department, University of Florida, Gainesville, FL, USA
[b] Food Science and Human Nutrition Department, Citrus Research and Education Center, University of Florida, Lake Alfred, FL, USA

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ABSTRACT

Prevention of microbial cross-contamination during postharvest handling is an important step to minimize microbial food safety hazards of produce. Dump tanks and flume systems are widely used in many states (e.g., Florida) to transfer/wash tomatoes, and are one of the most critical points where cross-contamination may occur. This study presents data gathered over three years (2013, 2014, and 2015) on tomatoes collected from five growing regions in Florida to evaluate the risk associated with postharvest processing of tomatoes in commercial packinghouses. A total of 840 and 839 composite samples, from pre- and post-processed tomatoes, respectively, were analyzed for aerobic plate count (APC), and total coliforms (TC) and generic *E. coli* (EC). The least square mean (LSM) value of APC for all samples (both pre- and post-processed) was 6.0 log CFU/tomato ($n = 840$), whereas the LSM for TC counts was 4.1 log CFU/tomato ($n = 839$). Ninety-one (10.8%) and 820 (97.7%) out of 839 samples of post-processed samples had TC and generic EC counts below the detection limit of 1.3 log CFU/tomato, respectively. APC and TC counts in post-processed samples were significantly lower ($p < 0.0001$) than those in the pre-processed samples. There was no significant difference ($p = 0.1011$) in the occurrence of generic EC pre- and post-process. APC and TC were significantly higher ($p < 0.0001$) on samples collected in 2014 than 2013 and 2015, while the generic EC levels were not significantly different between 2013 and 2014. All samples collected in 2015 were negative for generic EC. TC counts varied significantly ($p < 0.0001$) by season, with highest counts in summer and lowest in the winter, over the three-year period. APC were significantly ($p < 0.0001$) higher in summer and fall seasons as compare to winter and spring. Microbial loads were significantly higher in the northern sites compared to the southern sites. Tomatoes from site 5 (southernmost) had significantly lower APC and TC ($p < 0.0001$) than recorded from other four sites. Data from this research demonstrated that the postharvest wash treatments used at the packinghouse surveyed in this study effectively reduced the overall microbial load and prevented cross-contamination.

1. Introduction

Studies involving tomato packinghouses indicate that the tomato microflora most likely come from soil (Senter, Cox, Bailey, & Forbus, 1985; Schneider et al., 2017) and can contain organisms of fecal origin (e.g., *E. coli*). From 1990 to 2015, raw tomatoes have been implicated in 22 multistate outbreaks of foodborne illnesses (Bennett, Littrell, Hill, Mahovic, & Behravesh, 2015; CDC, 2016). Tomatoes may become contaminated in the field during harvest or handling, during postharvest processing in packinghouses, and during transportation (Zheng et al., 2017). Therefore, once harvested, care must be taken to prevent direct and/or cross-contamination of tomatoes during sorting, washing, packing and shipping. Several foodborne outbreaks associated with fruits and vegetables (Chaidez, Moreno, Rubio, Angulo, & Valdez, 2003; Scallan et al., 2011; Sivapalasingam, Friedman, Cohen, & Tauxe, 2004; Steyn, Cameron, Brittin, & Witthuhn, 2011), including tomatoes (Bennett et al., 2015; CDC, 2016; Reller, Nelson, Mølbak, & Mintz, 2006; Taylor, Kastner, & Renter, 2010) were traced back to packing operations. This emphasizes the need for more research to

* Corresponding author.
E-mail address: keiths29@ufl.edu (K.R. Schneider).
[1] Current address: Department of Food Science and Engineering, Beijing Technology and Business University, Beijing, China.

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characterize the microbial control measures in postharvest operations.

The prevention of microbial cross-contamination during postharvest handling is an important step to minimize microbial food safety hazards. Researchers have tested the efficacy of numerous chemical, physical, and biological methods to reduce the microbiological load from produce (Parish et al., 2003; Sreedharan, Li, De, Silverberg, & Schneider, 2017; Tomás-Callejas et al., 2012; Zhou, Luo, Nou, Lyu, & Wang, 2015). Dump tanks (i.e., flume systems) with sanitizers are widely used to transfer/wash tomatoes, and are one of the most critical points where cross-contamination can be prevented (Sreedharan et al., 2017; Zhou, Luo, Turner, Wang, & Schneider, 2014). Other washing methods, such as spray brush-beds, overhead spray-applied sanitizers and hydrocooling are also used to control microbial contamination (Chang & Schneider, 2012; Schneider et al., 2017; Tomás-Callejas et al., 2012). Flume and dump tanks have been shown to be less effective in removing microbial load from produce surfaces as compared to rollers utilizing overhead spray-applied sanitizers (Chang & Schneider, 2012). Flumes are still commonly used as they reduce the risk of bruising of the produce during transfer from field bins to the packing/washing line (Gereffi, Sreedharan, & Schneider, 2015; Zhou et al., 2014). Sometimes a flume system is used in conjunction with a brush roller to enhance produce cleaning. The water used in flume and dump tank systems can become a point of cross-contamination for spoilage organisms and plant pathogens, as well as human pathogens (Harris et al., 2003). Baker and Heald (1932) first reported on potentially harmful microbes that could accumulate in dump tanks and the subsequent need to disinfect process water. Since then, many studies on process water have been reported (Schneider et al., 2017; Sreedharan et al., 2017; Suslow et al., 2003). The prevention of cross-contamination varies with factors such as commodity type, wash system, soil type, contact time, detergent, water temperature, and wash water quality, especially if used from recycled or untreated sources (Parish et al., 2003). Disinfectant chemicals are used in wash water to provide an effective barrier against cross-contamination (Parish et al., 2003; Sreedharan et al., 2017; Zhou et al., 2014).

Many post-harvest operations rely on copious water contact during fruit unloading and washing (Tomás-Callejas et al., 2012). A single piece of contaminated produce can potentially cross-contaminate a large amount of clean product, resulting in an increased risk of foodborne illnesses (Danyluk & Schaffner, 2011). The accumulation of organic matter in flume/dump tanks can cause a decline in sanitizer concentration, allowing pathogen survival (Zhou et al., 2014), leading some packers to employ single pass water applications such as spray bars, or field pack product to eliminate washing altogether. Although many studies have evaluated farm-related factors influencing the microbial contamination of produce (Allen et al., 2013; Bohaychuk et al., 2009; Mukherjee, Speh, Jones, Buesingk, & Diez-Gonzalez, 2006, 2004; Orozco et al., 2008; Park et al., 2013; Wadamori, Gooneratne, & Hussain, 2017), only a few (Benjamin et al., 2013; Gereffi et al., 2015; Izumi, Poubol, Hisa, & Sera, 2008a, Izumi, Tsukada, Poubol, & Hisa, 2008b; Schneider et al., 2017) have examined the bacterial counts on produce as affected due to factors other than farming method. Most Florida packinghouses utilize flume-tanks (Schneider et al., 2017), though a small number of packers use brush roller systems, or a combination of the two. The typical sanitizing agents utilized in these systems are sodium hypochlorite (NaOCl), peroxyacetic acid (PAA), though several other lesser used sanitizers such as chlorine dioxide (ClO_2) are used as well. Although indicator microorganisms often do not show direct correlation to the presence/absence of pathogens (Grabow, 1996), heterotrophic bacterial counts or total coliforms are recognized as indicators of process performance and fecal contamination, respectively (Ashbolt, Grabow, & Snozzi, 2001; FDA, 2002). These indicator organisms are enumerated and monitored while carrying out evaluation of sanitizers in reducing pathogen loads and cross-contamination during postharvest processing of produces (Harris et al., 2003; Keskinen & Annous, 2011; Parish et al., 2003; Schneider et al., 2017; Tomás-Callejas et al., 2012).

This study presents data gathered from five growing regions in Florida, over a three-year period (2013, 2014, and 2015). Portions of the 2013 and 2014 data were used as part of a previously published, two-year, three-state survey of tomato handling practices, (Schneider et al., 2017), which included flumes, brush beds and dry pack operations. The objective of this new analysis focuses on the efficacy of fluming practices which are part of the Florida Tomato Good Agriculture Practices (T-GAPs) regulation to evaluate the effects of postharvest processing on microbial load. Tomatoes from commercial packinghouses in Florida were analyzed for aerobic plate counts (APC), total coliforms (TC) and generic *E. coli* (EC) on tomatoes; pre- and post-processing.

2. Materials and methods

2.1. Sampling sites and procedure

Round, green tomatoes were harvested from packinghouses located in five growing regions, shown in Fig. 1. Twenty composite samples consisting of five tomatoes each were collected pre- and post-processing from each site during each visit. Pre-processed tomatoes were aseptically sampled from 10 field bins or baskets (two composite samples from each bin or basket) or a single gondola (sampling from different locations around the perimeter). Post-processed composite samples were collected from boxes immediately after processing and packing at all sampling locations. All samples were placed in sterile plastic bags (15″ x 20”; Thermo Fisher Scientific, Pittsburg, PA), and were stored on ice, transported to the laboratory and analyzed within 24 h of collection.

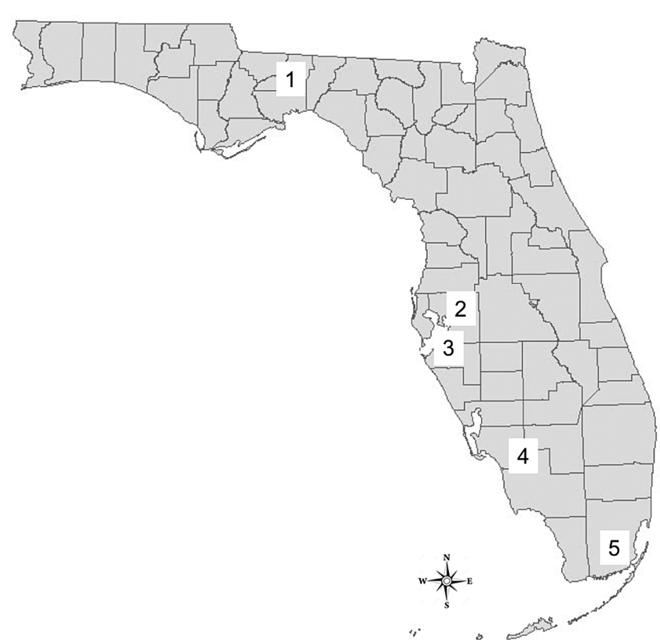

Fig. 1. Tomato sampling sites in Florida. Locations are marked with site numbers.