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Microbial evaluation of pre- and post-processed tomatoes from Florida, New Jersey and Maryland packinghouses

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ABSTRACT

Prevention of microbial cross-contamination during postharvest handling is an important step to minimize microbial food safety hazards. Dump tanks and flume systems are widely used in states like Florida to transfer/wash tomatoes, and are one of the most critical points where cross-contamination may occur. Some processors in states such as New Jersey, New York and California utilize dry dump systems, with or without overhead spray bars, to process tomatoes, while others states such as Maryland field-pack tomatoes. This study was conducted in 2013 and 2014, from five growing regions in Florida and New Jersey each and from four growing regions in Maryland. A total of 1600 and 1597 composite samples were analyzed for aerobic plate count (APC), and total coliforms (TC) and generic E. coli (EC), respectively, from both pre- and post-processed tomatoes. Seventeen samples for APC and 72 for TC had counts outside the countable range and failed to provide any valid result, and were not included in the final data sets. The least square mean (LSM) value of APC for all samples (both pre- and post-processed) was 6.8 $\log_{10}$ CFU/tomato (n = 1583), whereas the LSM for TC counts was 4.9 $\log_{10}$ CFU/tomato (n = 1438). Ninety out of 1528 (5.9%) and 1498 out of 1597 (93.8%) samples had TC and EC counts below the detection limit of 1.3 $\log_{10}$ 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. There were significantly higher (p < 0.0001) APC and TC on samples collected in 2014 than 2013, while the EC levels showed no significant differences between years. TC counts varied significantly (p < 0.0001) by different growing seasons, with highest counts in summer, over a two-year period, while APC varied significantly (p < 0.0001) in summer and fall vs. winter and spring. APC and TC counts were positively correlated. Tomatoes from FL had significantly lower APC and TC (p < 0.0001) than those from NJ and MD. Despite the potential for increasing microbial contamination resulting from improperly maintained water systems, many packinghouses will continue using existing washing practices to prevent cross-contamination.

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1. Introduction

Leafy greens, tomatoes, melons, sprouts, and berries have all been frequently associated with foodborne illness outbreaks (Sivapalasingam, Friedman, Cohen, & Tauxe, 2004). The bacterial pathogens typically associated with these foods include Shiga toxin-producing E. coli (STEC), Salmonella spp., Shigella spp., and Listeria monocytogenes (Brackett, 1999; Frank et al., 2011; Park et al.,

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2015; Reller, Nelson, Mølbak, & Mintz, 2006). Between 1998 and 2008, of the 21 vine-stalk vegetable-associated outbreaks, 19 (90%) were attributed to tomatoes (Jackson, Griffin, Cole, Walsh, & Chai, 2013). Once tomatoes are harvested, care must be followed to prevent direct and/or cross-contamination of the crop during sorting, washing, packing and shipping. Dump or flume tank systems are widely used in commercial tomato packinghouses (Zhou, Luo, Turner, Wang, & Schneider, 2014). Other washing methods, such as spray brush-beds, can reduce microbial loading as well as prevent cross-contamination on tomato surfaces (Chang & Schneider, 2012; Tomás-Callejas et al., 2012), while some tomatoes are field-packed and are not washed at all. Several foodborne illness outbreaks associated with fruits and vegetables (Chaidez, Moreno, Rubio, Angulo, & Valdez, 2003; Scallan et al., 2011; Sivapalasingam et al., 2004; Steyn, Cameron, Brittin, & Witthuhn, 2011), including tomatoes (Bennett, Littrell, Hill, Mahovic, & Behravesh, 2015; CDC, 2011; Reller et al., 2006; Taylor, Kastner, & Renter, 2010) have been traced back to packing operations, and more research is needed to characterize the microbial control measures in packinghouse operations.

Researchers have explored the efficiency of numerous physical, chemical, and biological methods for reducing the microbiological load of produce (Parish et al., 2003; Tomás-Callejas et al., 2012; Zhou, Luo, Nou, Lyu, & Wang, 2015). Flume-tanks, overhead spray-applied sanitizers and hydrocooling are all used to control microbial contamination. The use of sanitizers in post-harvest flume and dump tanks reduces cross-contamination (Chang & Schneider, 2012) and is the critical step in the tomato packinghouse processing (Rushing, Angulo, & Beuchat, 1996). Flume and dump tanks may be preferred as risk of bruising of the produce surface is comparatively less than other methods (Gereffi, Sreedharan, & Schneider, 2015; Zhou et al., 2014), however, flume and dump tanks may also be less effective in controlling cross-contamination compared to overhead spray-applied sanitizers (Chang & Schneider, 2012). The water used in flume and dump tank systems can also become a point of cross-contamination for spoilage organisms and plant pathogens, which may lead to quality loss and decay, as well as human pathogens that can cause outbreaks of foodborne diseases (Harris et al., 2003). The potential accumulation of microbes in dump tank water as well as the need to disinfect this water to minimize quality defects in produce was identified as early as 1932 (Baker & Heald, 1932) and continues to be reported (Suslow et al., 2003; Zhou et al., 2015). Washing efficiency varies with factors such as commodity, wash system type, soil type, contact time, detergent, water temperature, and wash water quality, especially if recycled or untreated prior to reuse (Parish et al., 2003). Disinfectant chemicals are used in wash water to provide an effective barrier to cross-contamination (Parish et al., 2003; Park, Gray, Oh, Kronenberg, & Kang, 2008; 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 illness (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; Park et al., 2013, 2014, 2015; Mukherjee, Speh, & Diez-Gonzalez, 2007; Mukherjee, Speh, Dyck, & Diez-Gonzalez, 2004; Mukherjee, Speh, Jones, Buesingk, & Diez-Gonzalez, 2006; Orozco et al., 2008; Strawn, Fortes et al., 2013; Strawn, Grohn et al., 2013), only a few (Benjamin et al., 2013; Gereffi et al., 2015; Izumi, Poubol, Hisa, & Sera, 2008; Izumi, Tsukada, Poubol, & Hisa, 2008) have examined the bacterial counts on produce as affected by factors other than farming method. This study presents data gathered over two years (2013 and 2014) on tomatoes collected from 14 growing regions in Florida (5), Maryland (4) and New Jersey (5) to evaluate the risk associated with post-harvest processing of tomatoes in commercial packinghouses. Most Florida packers utilize flume-tanks, though a small number of packers use brush roller systems, or a combination of the two. The typical sanitizing agent utilized in these systems was sodium hypochlorite (NaOCl) and/or peroxyacetic acid (PAA). Packing facilities studied in Maryland did not wash their tomatoes or use chemicals in their post-harvest processing, typical of many small and medium growers in the state. Growers in New Jersey use flume-tank, spray bars, and/or brush rollers, with the primary chemical treatment being PAA or NaOCl. This study may help to identify areas for improvement in packinghouse operational procedures that could reduce the risk of potential microbial contamination.

2. Material and methods

2.1. Sampling sites and procedure

Tomatoes were collected from packinghouses located at 14 growing regions shown in Fig. 1. Tomatoes were harvested when green in color in Florida, red in Maryland, and pink to red in New Jersey. Growers at two of the four sampling locations in Maryland field packed their tomatoes (a common practice among small/medium growers), while at the other two locations they packed the tomatoes after using a dry-brush line. Twenty composite samples consisting of five tomatoes each (n = 100) were collected pre- and post-processing from each site during each visit. Pre-processed tomatoes were aseptically sampled directly from the tomato field at locations, where growers field-packed their tomatoes. At other locations tomatoes were collected 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 harvesting and packing (at locations which field-packed tomatoes) or after processing and packing at the remaining 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.

2.2. Microbiological analysis

One hundred ml of 0.1% (w/v) sterile peptone water (PW) (Thermo Fisher Scientific, Waltham, MA) was added to the sterile sample bags and each tomato was rubbed for 60 s to remove surface bacteria. Sodium thiosulfate (0.6% w/v) (Thermo Fisher Scientific, Waltham, MA) was added to PW to quench any residue sanitizer activity. Bacterial enumeration was performed by 10-fold serial dilution in 0.1% (w/v) PW. One hundred μl of each dilution was spread plated onto plate count agar (PCA) (Thermo Fisher Scientific, Waltham, MA) to determine total mesophilic aerobic plate counts (APC) and on CHROMagar™-ECC (DRG International, Inc., Mountainside, NJ) to determine total coliform (TC) and generic EC counts. PCA plates were incubated at 30 °C for 48 h and CHROMagar™-ECC plates were incubated at 37 °C for 24 h. The lowest limit for detection of microbes was $1.3 \log_{10}$ CFU/tomato and 25–250 CFU/plate was considered as the countable range for any dilution.