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An Assessment of Produce Growers' Sanitizer Knowledge and Practices on the Correct Use of Sanitizers

ABSTRACT

Sanitizer use in post-harvest produce washing is a common practice to reduce microbial contamination of wash water, reducing transfer and dispersal of pathogenic bacteria on fresh produce. Understanding growers' sanitizer-use knowledge and current practices may guide development of educational materials and thus fill knowledge gaps. A survey examining sanitizer-use practices was delivered to produce growers in Virginia representing very small (48%), small (35%) and large (17%) farms. Eighty-two percent of respondents used some type of wash system to wash their produce. Chlorine was the most common sanitizer used (75%), most commonly delivered through a spray bar (40%). Over 34% of growers used concentrations of sanitizer that did not fall within the recommended concentration range for the specific use or were unsure of the sanitizer's concentration. Generally, extension agents and growers' meetings were the preferred sources of education (78%). Results demonstrate the importance of extension as a delivery system for fresh produce growers. Often, sanitizer-use education, although part of extension food safety trainings, is not the primary focus. To increase the percentage of growers using correct concentrations/application, more targeted, in-depth education on improved sanitizer use in pre- or post-harvest wash water may be necessary.

INTRODUCTION

Sanitizers are commonly used in produce washing operations to prevent cross-contamination of fresh produce through wash water, subsequently reducing pathogen populations on produce surface *(2, 3, 11)*. The Food Safety Modernization Act (FSMA) Produce Safety Rule does not require the treatment of wash water with a sanitizer, but it does require water to be safe and of adequate sanitary quality for its intended use in produce washing operations *(13)*. Fresh produce growers commonly use sanitizers such as chlorine (liquid chlorine and hypochlorites), peracetic (peroxyacetic) acid (PAA), chlorine dioxide or ozone during

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produce washing to reduce microbial contamination of wash water, thereby minimizing cross-contamination *(2, 3, 4, 7, 11)*. When sanitizers are used to treat wash water, they must be approved for use in water that contacts fresh produce. Chlorine-based sanitizers are the most widely used in the fresh produce industry *(2, 3, 8)*. The highest antimicrobial activity occurs when most of the chlorine is its free form *(8)*. This is highly dependent on pH, temperature of the water and amount of organic matter present *(3, 8)*. Therefore, maintaining adequate sanitizer concentration in wash water using chlorine can be challenging, and the concentration of free chlorine must be monitored *(3, 8)*. The antimicrobial activity of PAA is less dependent on pH and organic matter and is therefore often viewed as a better sanitizer choice. Overall, inclusion of recommended concentrations of chlorine and PAA sanitizers in wash water can effectively reduce microbial populations by 1–2 log units on produce surfaces *(4, 7, 11)*.

Grower sanitizing practices can vary widely, with some growers not using sanitizers in wash water at all, or using incorrect or non-recommended practices, such as using incorrect concentrations (too high or too low) or using liquid soap or other household cleaners *(5, 10)*.

A survey comparing grower practices between 1999 and 2016 documents a significant increase in the frequency of sanitizer usage to clean harvest tools but does not document post-harvest sanitation practices *(1)*. Therefore, it is hypothesized that over the past two decades, a larger percentage of growers are utilizing sanitizers in their daily operations. The purpose of this study is to obtain information on how fresh produce growers currently utilize sanitizers in their operations. The overall goal is to determine whether growers are utilizing sanitizers correctly or if further, focused training is needed to address specific sanitizer use/application practices.

MATERIALS AND METHODS

Data was collected using a survey tool that evaluated (1) how produce growers use sanitizers in their daily operations and (2) preferred delivery methods for educational materials. Paper surveys were delivered in person to produce growers attending Cooperative Extension grower meetings during winter 2017. All growers attending the meeting (regardless of farm size) were included in the survey. The educational content the growers received during these meetings varied and was not associated with the survey content. For example, selection of correct sanitizers was not discussed at these meetings. At the beginning of each meeting, attendees were given a brief verbal introduction about the survey and the survey was distributed. The survey protected their anonymity and participation was voluntary. All parts of this study were approved by the Virginia Tech Institutional Review Board (IRB # 16-817).

Pilot test

Survey questions were pilot-tested at a single grower meeting with 22 participants. This was conducted to ensure that growers could understand the terminology used to frame survey questions and to ensure that answer choices for multiple choice questions were appropriate. Questions were revised based on the participants' feedback, and revisions were incorporated into the final survey.

Survey

The survey consisted of 12 questions: nine multiple-choice, one fill-in-the-blank, and two open-ended questions. The survey had four main sections: (1) questions about wash systems (type and concentration of sanitizer used and methods of monitoring); (2) factors influencing adoption of a new sanitizer and their preferred source of information; and (3) demographics (duration of farming, farm location).

Data analysis

Responses from the surveys were gathered and organized according to the corresponding questions in the survey. Response rate (%) for each question was determined and the percentage of answers for each question was calculated. Data was analyzed using Microsoft Excel (MS Excel, Redmond, WA). Growers' sanitizer-use practices and the top three influencers of their adoption of a sanitizer were identified.

RESULTS

Data was collected at grower meetings conducted across VA between January and May 2017. Sixty-five completed surveys were collected and analyzed.

Demographics

Produce growers in the meetings represented very small (48%), small (35%), and large (17%) farms. This classification is based on the average annual monetary value of produce sold, on a rolling basis, during the previous 3-year period. Most growers had been farming for less than 10 years (37%) or more than 10 years (47%). Two respondents indicated that they had "just started," and one claimed to have been farming "all my life."

Sanitizer use practices

Primary information retrieved from questions on sanitizer use practices included types of systems used to wash produce, types of sanitizers used to wash produce, concentration of sanitizer used, and types of monitoring systems used to measure sanitizer concentration. Eighty-two percent of respondents (50/61) used a wash system to wash their produce. Of those, a spray bar was the most common system used (40%), followed by a dump tank (35%) and flume (12%) *(Fig. 1)*. "Triple sink," "water hose," "stainless steel trough," "laundry sink," and "hand wash stations" were among "other" systems used (14%)

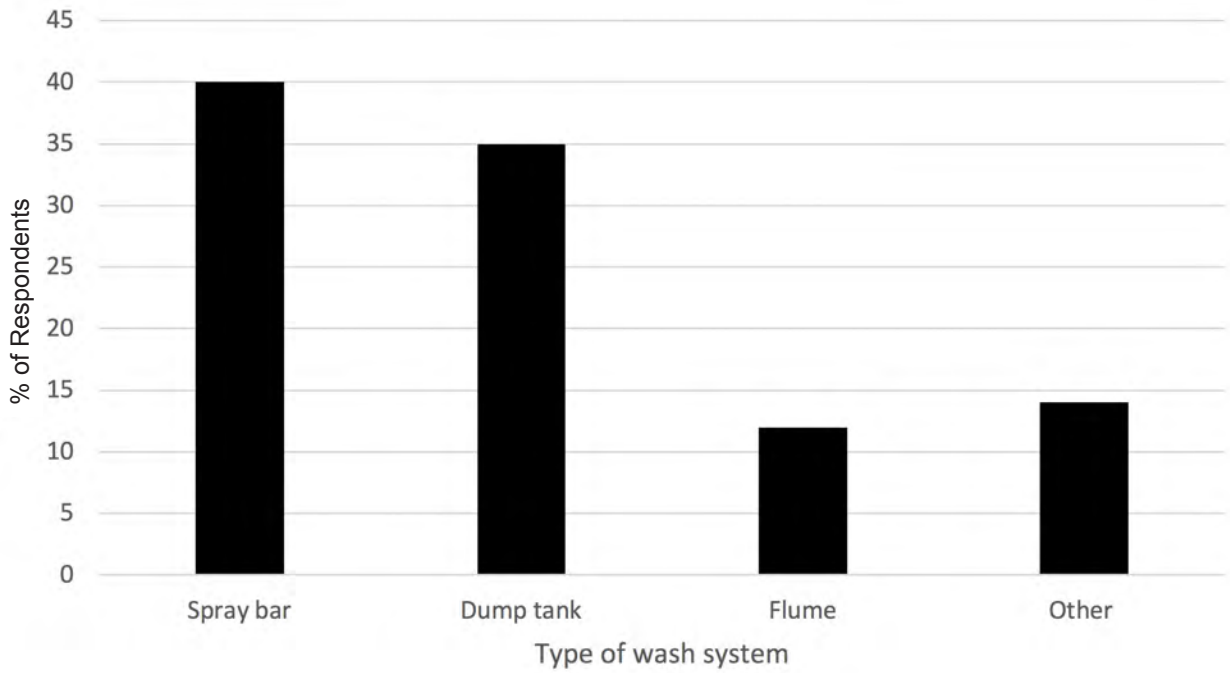

Figure 1. Types of wash systems used by produce growers in VA (n = 50).
Other = hand wash (1), triple sink (2), stainless steel trough (1), laundry sink (1), water hose (2).

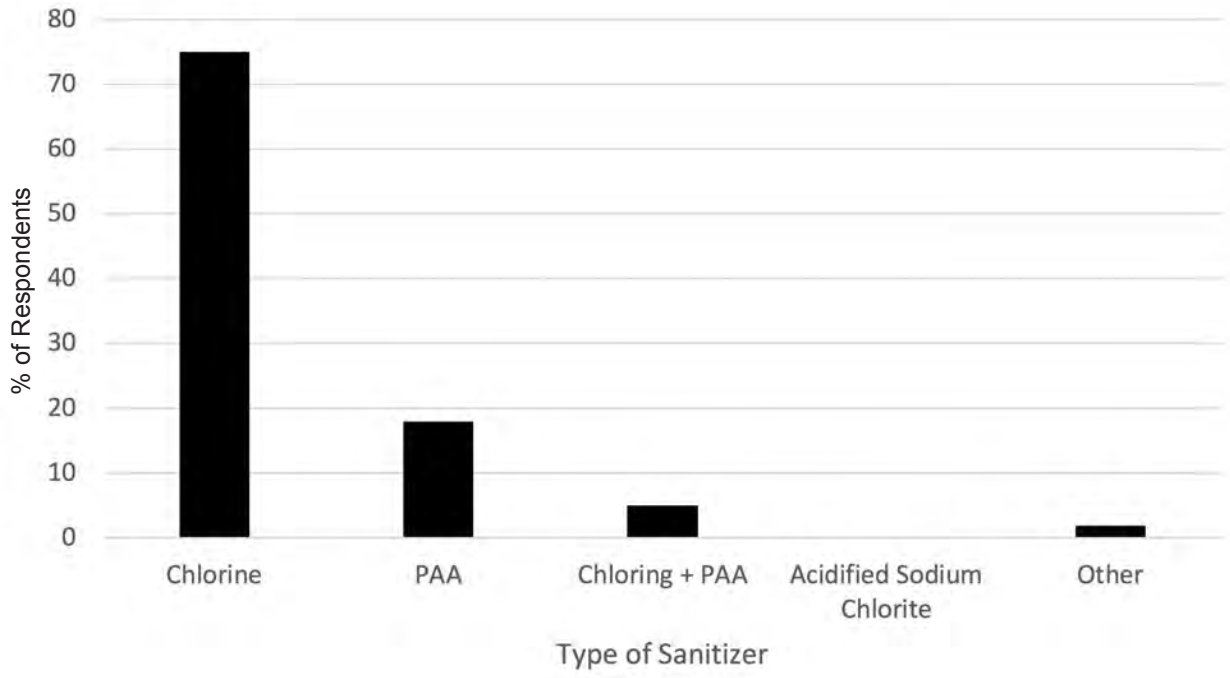

Figure 2. Types of sanitizer used by produce growers (n = 44).
***PAA (peroxyacetic acid). Other = detergent. 27% (17/64) did not use sanitizer and 5% (3/64) did not respond to the question.**

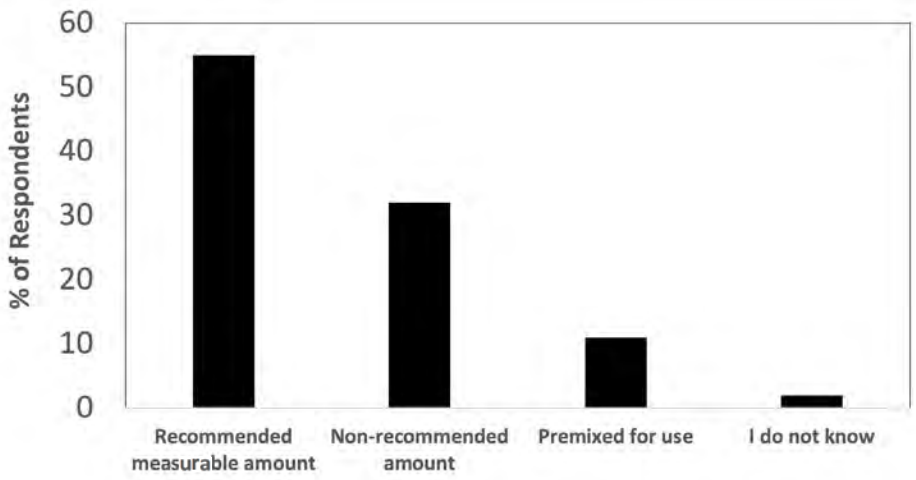

Figure 3. Percent of respondents (growers) who used sanitizers in their recommended amounts (either according to product label or other generally recognized concentrations, i.e., ½ – 1 tablespoon household bleach to 1 gallon = 50–100 ppm) to wash produce (n = 44).

(Fig. 1). Of the respondents using a wash system, 27% of respondents did not use sanitizer. Of the remaining %, the majority (75%) used chlorine-based sanitizers *(Fig. 2)*. The survey then asked the respondents to describe either (1) the concentration (ppm) of sanitizer used, (2) the volume of sanitizer (tablespoon, teaspoon, cup, other) added to volume of water (gallons, quarts, other) to mix their sanitizer, (3) whether the sanitizer was premixed, or (4) whether they did not know the concentration. Based on intended use and sanitizer type, the description growers provided was analyzed to determine whether the self-described amount would be considered "recommended" or "non-recommended." Most respondents (55%) used the concentration recommended by the manufacturer; however, 34% were either unaware of their sanitizer's concentration or used non-recommended concentrations *(Fig. 3)*. Examples of using non-recommended chlorine concentrations included using higher concentrations for spray bar systems and not accurately measuring concentrations (e.g., capful to sink full, and using "detergents" for sanitation). Select growers' responses to chlorine use concentrations in different types of wash systems are provided in *Table 1*.

A high percentage (87%) of respondents measured the concentration of sanitizer they used; however, the remaining either did not measure it at all or used smell as an indicator *(Fig. 4)*. Use of oxidation-reduction potential (ORP) meters and chlorine concentration test strips were the most common methods used to monitor sanitizer concentration and were used with equal frequency by the growers *(Fig. 4)*. A few respondents (2%) mixed the sanitizer in wash water on each day of use to maintain sanitizer concentration (referred as "other" in *Fig. 4*).

Finally, growers were asked to rank the top three characteristics that they used to determine the type of sanitizer they use for their operation. The top three characteristics that growers considered in selecting type of sanitizer were cost (44%), effectiveness (23%) and ease of use (12%). Other conditions that growers included were availability, regulations, and audit programs. A few respondents also mentioned buyer requirements as a consideration.

Preferred delivery method for educational materials

Cooperative extension was identified as the preferred source of current information on produce washing (43%), followed by state and national produce growers' meetings (36%), other growers (8%) and the Internet (6%). A small percentage of growers mentioned websites and other extension agencies, including Good Agricultural Practices (GAP) guidelines, GAP auditors and organic certifiers as their preferred sources of current information. For seeking information on produce washing and antimicrobial resistance (AMR) in the future, "growers' meetings" was selected by 37% of respondents, followed by extension specialists (26%), written fact sheets (22%), online trainings (9%), and video recordings and audio/podcasts (6%).

DISCUSSION

Sanitizer use practices

The FSMA Produce Safety Rule does not require addition of sanitizers to wash water, but if they are used, they are required to be monitored at a frequency adequate to ensure that the treated water is consistently safe and of adequate sanitary quality for the intended use *(14)*. In the past, maintaining the microbial quality of produce wash water

TABLE 1. Selected responses to question about concentration of chlorine sanitizer used by produce growers who use wash system in VA

Wash System	Sanitizer concentration
Hand wash*	1 tablespoon sanitizer in 1 gallon of water
Dump tank*	capful of sanitizer to sinkful of water
	1.5 cup sanitizer in 1 gallon of water (~ 10% solution)
	1:10
	200 ppm
	100–200 ppm
	150 ppm
	80 ppm
Spray bar*	150 ppm
	3 teaspoons of sanitizer in 5 gallons of water (~ 50 ppm)
	7 teaspoons of sanitizer in 10 gallons of water (25–50 ppm)
	4–7 ppm
Flume*	150 ppm

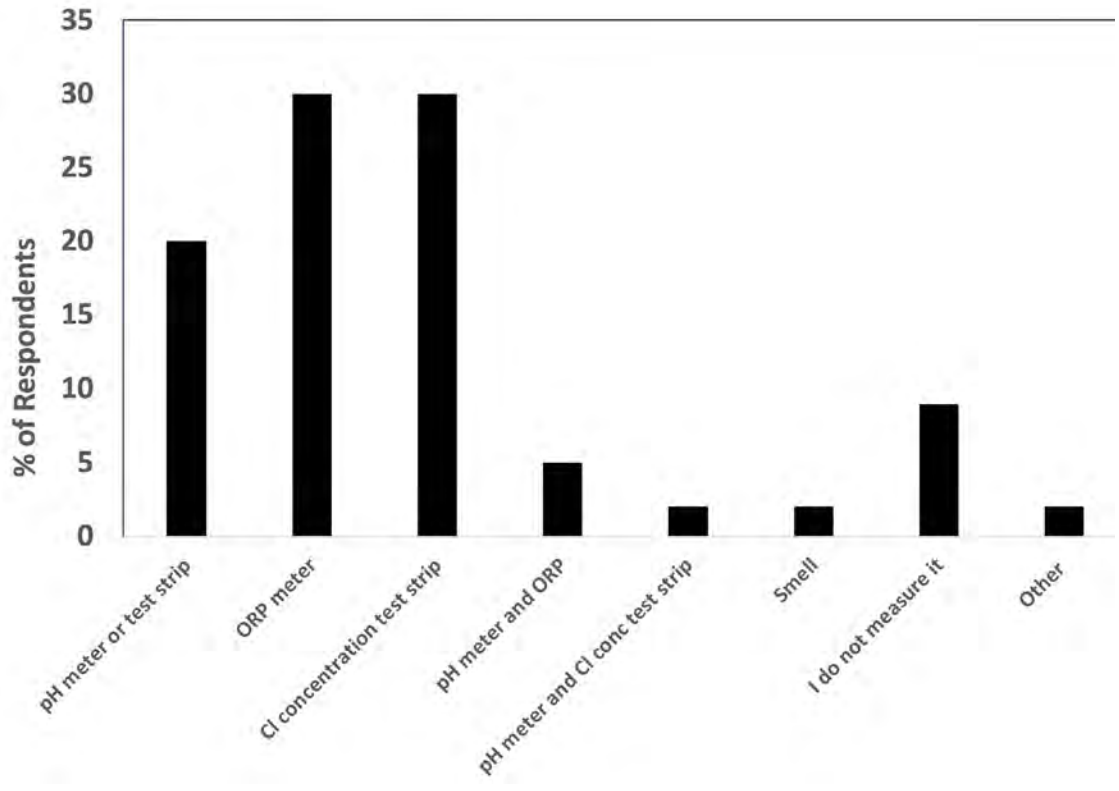

FIGURE 4. Methods produce growers use to measure concentration of sanitizer added to fresh produce wash water (n = 44).

has not necessarily been viewed by growers as an important behavior and has been identified as a key area needing improvement in several studies *(5, 6, 10, 12)*. A survey conducted in Kentucky found that only 36% of survey respondents recognized that produce wash and rinse water was a potential source of microbial contamination *(12)*. Additionally, postharvest treatment of water was identified as one of the needed areas of improvement among Minnesota farmers *(6)*. Harrison et al. *(5)* reported use of unapproved sanitizers, such as vinegar, detergents, ammonia and water, and sulfur/citric acid solutions, in several states in the Southeastern U.S., further identifying produce washing as a practice that specifically needed attention to reduce the risk of foodborne illnesses. In a more recent study, 75% of growers surveyed agreed that the addition of sanitizer to postharvest water helps reduce the microbial load *(9)*.

Not surprisingly, this study discovered a wide spectrum of sanitizer use practices among produce growers. As previously stated, chlorine-based sanitizers have been the most commonly used sanitizers in the fresh produce industry for decades *(2, 3, 8)*. Unfortunately, the antimicrobial activity of these sanitizers depends on several factors, including water temperature, pH, water hardness, contact time, amount and rate of product throughput, type of product, water to product ratio, amount of organic material, and the resistance of pathogens to the particular antimicrobial agent *(13)*. Sanitizer selection and concentration depends specifically on wash water system (e.g., spray bar, recirculated), organic load, type of produce, and volume of produce, among other variables/factors. There is no universal recommendation for all wash water practices, which makes it difficult to meet specific grower needs. Furthermore, when using chlorine, it is extremely important to monitor free chlorine concentration to ensure that the wash water is effective, because chlorine binds to organic material in the water. Chlorine-based sanitizers were the most common sanitizers used by the produce growers surveyed in this study, although concentrations added were often incorrect, or were not consistently measured to ensure use of recommended concentrations. We observed that about half of the growers surveyed used sanitizer concentrations that were too high or too low, or did not know what concentrations they use. Consistently using correct sanitizer concentrations is a common problem for growers *(5, 10)*. For example, 16% of growers in New York added chlorine at correct levels (for their intended use) ranging from 50–200 ppm *(10)*. Because of the increased emphasis on fresh produce safety and grower practices over the last two decades, we expected a higher percentage of growers to be using sanitizers correctly. Unfortunately, even if concentrations used are initially correct, the amount of free chlorine can change rapidly during the wash period; therefore, monitoring is essential. Our study found that as many as 20% of growers either do not monitor sanitizer concentrations at all or measure it through non-recommended methods, such as smell. Our survey did not ask about frequency of monitoring, but it has been previously reported to vary significantly *(5, 10)*. Overall, this study shows improvement in sanitizer usage (compared with previous studies), but it is clear that a more targeted educational campaign is needed to provide Virginia growers with specific recommendation based on their intended use.

Preferred delivery method for educational materials

There have been many surveys assessing preferred educational delivery methods for growers. As discovered in this study, growers rely on education and training opportunities from several types of resources. There is great interest in GAP training programs through online trainings, websites or videos; however, cost and lack of time are often primary barriers *(12)*. On-farm food safety trainings contribute to increased knowledge and perceptions of food safety practices among growers, but it is important to understand the practical barriers confronted by growers to implementing these practices and to utilize that knowledge for developing effective educational and outreach plans *(9)*. In this study, we identified a preference on the part of growers to get information (e.g., on produce washing) from Cooperative Extension through grower meetings. This data could be biased, however, because the survey was conducted with participants already engaging with cooperative extension at a grower meeting. A small percentage would also want to receive educational materials through written fact sheets, online trainings, video recordings, audio/podcast. In Virginia, future plans for implementing additional training for growers on the topic of post-harvest water sanitation will be a multi-pronged approach, including clientele we already interact with at grower meetings, but expanding to include distance learning video recordings and podcasting to broaden our reach, as well as one-on-one consultations in sanitizer use to improve correct usage.

CONCLUSIONS

Human pathogenic bacteria can be transmitted through contaminated water; therefore, managing wash water quality during post-harvest washing can play a key role in mitigating food safety risks. Water parameters, such as initial microbial quality, pH, temperature, and turbidity, affect appropriate sanitizer selection for use with various types of produce and washing systems. Selecting the correct sanitizer and using the recommended concentrations in wash water maintains the microbial quality of wash water and prevents cross-contamination of produce. Produce growers are not necessarily aware of the importance of using recommended concentrations and therefore may not follow the standard protocols to prepare and monitor sanitizer. This study found that far too many growers were using incorrect concentrations of the sanitizers that they were using. This

shows a clear need for educational interventions specifically targeting sanitizer selection, method of preparation, use, and monitoring as well as best practices to manage water quality depending on the commodity and wash system. Growers have a clear preference for receiving this type of information in small settings, such as growers' meetings, via familiar people, such as extension agents.

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