For More Information—
Consumer Resources on Safe Handling of Produce

ProducePro
Partnership for Food Safety Education and the US Food and Drug Administration co-developed Produce Pro: colorful FREE materials to help you teach smart produce-handling practices that make everyone a ProducePro. www.fightbac.org/food-safety-education/safe-produce

Produce: Selecting and Serving it Safely
FDA web page includes companion video and English and Spanish language text.
www.fda.gov/Food/FoodborneIllnessContaminants/BuyStoreServeSafeFood/ucm114299.htm#prep

Science-based Research on Produce Washing

USDA Nutrition Evidence Library Systematic Review Question: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes and to what extent do US consumers follow them? www.nel.gov/topic.cfm?cat=3100

Co-operative Extension Bulletin #4336, Best Ways to Wash Fruits and Vegetables
Department of Food Science and Human Nutrition at the University of Maine: researchers tested three commercial wash treatments. https://extension.umaine.edu/publications/4336e/

Removal of Trace Pesticide Residues from Produce
Department of Analytical Chemistry, the Connecticut Agricultural Experiment Station
A three-year study showed that rinsing under tap water significantly reduced pesticide residues. Four fruit and vegetable wash products were found to be no more effective at removing pesticide residues from produce than either a 1% solution of dishwashing liquid or rinsing under tap water alone.
www.ct.gov/caes/cwp/view.asp?a=2815&q=376676

What About Produce Washes?
BAC Fighter Knowledge Exchange
Thursday, July 21, 2016 with guest Robert J. Whitaker, Ph.D.,
Chief Science & Technology Officer, Produce Marketing Association
Moderator: Mary Saucier Choate MS, RDN, LD, Manager, Outreach and Stakeholder Engagement, Partnership for Food Safety Education

Original Script.
[Mary] Hi everyone! Welcome to our BAC Fighter Knowledge Exchange Conference Call: What About Produce Washes? This is Mary Saucier Choate, Manager of Outreach and Stakeholder Engagement at the Partnership for Food Safety Education and also the moderator of our call today. Thank you for joining us today for our Knowledge Exchange topic – What About Produce Washes?

Dr. Whitaker is the Chief Science & Technology Officer for the Produce Marketing Association. In this role, Dr. Whitaker has responsibility for food safety and security, environmental sustainability and technical innovations for the produce supply chain, from field to fork. Among other topics, Dr. Whitaker is an expert in commercial produce wash water management for use in agricultural production.

Before we begin a brief interview with Dr. Whitaker, I'd like to review the current consumer advice about washing of fresh fruits and vegetables.

The U.S. Food and Drug Administration recommends the following for consumer food safety:

- Wash all produce thoroughly under running water before preparing and/or eating, including produce grown at home or bought from a grocery store or farmers' market. Washing fruits and vegetables with soap, detergent, or commercial produce wash is not recommended.

- Even if you do not plan to eat the skin, it is still important to wash produce first so dirt and bacteria are not transferred from the surface when peeling or cutting produce.

- Scrub firm produce, such as melons and cucumbers, with a clean produce brush.

- After washing, dry produce with a clean cloth towel or paper towel to further reduce bacteria that may be present on the surface

Tested visual tools for promoting safe handling of fresh produce can be found with the Partnership for Food Safety Education's ProducePro found at fightbac.org

Questions for Dr. Whitaker

Q. [Mary] Dr. Whitaker I think all of us would be interested in knowing, before lettuce and other salad greens end up at the grocery store, what kind of antimicrobial process wash is used on these products, if any?

A. [Bob Whitaker] – Commercial fruit and vegetable wash processes. Many fresh produce items are washed to remove dust or dirt that might have been deposited on them while they grew in a field or in a closed environment like a greenhouse. Wash systems use combinations of spray bars and rapid water currents and even air bubbles to loosen dirt. Nearly all fresh produce that is washed prior to packing is washed with water that is treated with a water sanitizer like sodium hypochlorite, or chlorine or perhaps chlorine dioxide or other common wash water disinfectants like per acetic acid or PAA. These different products all behave a bit differently, but they are all there to do the same thing: kill any microorganisms that wash off of the surface of the produce and into the water so that they cannot re-attach to the raw products as they move through the wash system and spread to the whole batch being washed. It is important to note what I did not say; I did not say kill the microorganisms that live on the surface of the produce. It is a common misconception that using wash water treated with a disinfectant will sanitize the surface of the produce. That simply is not the case. Produce items vary greatly in the number and type of microorganisms that naturally can be found on their surfaces, but generally the total population can range from as few as 100 per square centimeter to more than one hundred million per square centimeter.

Under the best of conditions, a commercial produce wash system might reduce the microbial population that naturally resides on the surface of the product by 1-2 logs or 10 to 100-fold; for example, a batch of spinach with one million microorganisms per centimeter might come out of a well operated wash system with 10,000. Now that is not really a bad thing; most of these microorganisms naturally occur in in the production environment and have no effect on humans who consume them. They do not cause disease in humans and, in fact, are part of the natural environment and may help the plant ward off plant pathogens that can kill the plants, some help in the natural decay of plant materials to improve soil health and still others are helpful for human digestion of nutrients.

It is only when human pathogens like *Salmonella* or *E. Coli* O157H:7 enter the production environment and transfer onto the surface of the fruit or vegetable that we need to be concerned. That is why growers have Good Agricultural Practices or GAP programs in place and why Congress passed the Food Safety Modernization Act or FSMA and FDA developed the regulations under the Produce Rule from FSMA - to reduce the risk of contamination with human pathogens during the growth, harvest, cooling and packing of fresh produce; it's really the first line of defense for growers and consumers.

Another line of defense is a properly designed and operated commercial wash process where the wash water sanitizer kills any microorganisms, including human pathogens if they are present, that wash off into the water. The science for proper control of commercial wash systems is advancing rapidly. Just three weeks ago at the Center for Produce Safety Research Symposium, there were several presentations dealing with this subject. In general, it is recommended that these systems have at least 10 ppm free chlorine present at all times, maximize the amount of time the produce is actually in contact with the water/disinfectant mixture and keep the water as clean as possible so that dirt or organic material that washes off of the produce does not bind up all the disinfectant so that it becomes ineffective against microorganisms. For commercial manufacturers, the Preventive Controls Rule mandates that operators validate that their wash conditions are effective in controlling microbial populations in wash or cooling water and that they verify that these conditions are followed every time the wash system operates.

Q. [Mary] So, today we really wanted to give a short overview of produce washes or so-called “veggie washes” that consumers are able to buy at retail stores. Can you give us an overview of the efficacy of these consumer produce washes? I will also note that the FDA does not recommend use of these washes by consumers at home.

A. [Bob Whitaker] – overview of efficacy of consumer produce washes. I think it is interesting to note that the FDA does not recommend the use of these products and it is important to try to understand why. First and foremost, is the nature of produce and the interaction between microorganisms and plant surfaces. We look at the surface of a lettuce leaf or a tomato fruit and we see a pretty smooth surface with our own eyes. However, if you were to look at that same surface under a microscope, it might look more like the Grand Canyon. It has a large number of nooks and crannies, over-hangs and cliffs; in other words; great places for bacteria to hide. And that is exactly what bacteria do; they attach to these surfaces and "hide" from anything that might disturb them; remember, they just want to survive and grow and so a well-protected environment that does not subject them directly to the sun and it's killing UV rays or the desiccating wind is ideal. In fact, bacteria like these types of niches so well that they also produce polysaccharides and biofilms so that they can attach themselves almost like glue to the surface of the fruit or vegetable. These little indentations in the fruit or vegetable surface also protect against wash water and disinfectants. Fruits, leaves and roots are biological materials and, as such, they have electrical charges in the epidermis or skin that covers them. Sometimes these electrical charges are act hydrophobically; in other words, they repel the water so that sanitizers never get to the surface where the bacteria might be. Remember, successful "kill" by a wash water sanitizer at the surface of a produce item is determined by concentration and contact time, but if the sanitizer cannot be delivered to the surface, it can never be successful.

Another thing I think is important to remember about consumers washing produce is the fact that bacteria need moisture to grow. So if a consumer washes a cantaloupe or an apple or a pepper and doesn't get the fruit completely dry and leaves it unrefrigerated; even for just a day, even though the chances are exceedingly small that a pathogen might be present, the potential is there for a minor contamination of just a few pathogen cells that likely would not have caused illness, to now grow and reach a dose that could cause illness.

Lastly, pre-washed products that come in a bag; like a bagged salad, apple slices or carrot pieces have already been washed prior to packing in commercial systems and then packaged in specific protective packaging and stored cold. Removing previously washed products from these packages to wash them again may actually increase the risk that they could become contaminated by microorganisms that might be on the preparer's hands, on knives or cutting boards that have been used to prepare other foods or simply your kitchen counter.

So it is with that backdrop that you can understand FDA's long-held position and look at some of these retail "veggie" washes.

Q: [Mary] Some brands of consumer produce wash have done comparative studies. Can you talk about these and interpret their results for us?

A: [Bob Whitaker] - Comparative studies of "veggie" washes. There have been a number of studies looking at various types of consumer fruit and vegetable wash products over the years. These studies have been conducted by some of the best known and well-respected food scientists and microbiologists in the U.S. But, it is hard to compare them because the experimental designs, pathogen strains selected and methods used to compare the ability of these sanitizes to kill pathogens are not consistent. However, in preparing for today's webinar, I did look at a selection of research papers and a few things do stand out:

- The ability of sanitizer to kill harmful pathogens is often dependent on the genetics of the pathogen itself. For example, a sanitizer may be more effective against *Listeria* and less so against *Salmonella*. Fishburn saw this in his 2012 paper where using his protocols, chlorine bleach was much more effective against *Lm* than any of the other sanitizers tested: a veggie wash product, electrolyzed water, ozone or just running water. Given the increasing knowledge base that has accumulated in the last few years with the emergence of whole genome mapping and proteomics, it is also likely that comparative studies within pathogen strains would also show variability to susceptibility to specific sanitizers, i.e. it's just not *Salmonella* versus *Lm* or *E. coli*, but within different *Lm* strains, one might expect to find some *Lm* isolates to be more or less sensitive to certain sanitizers and the same would be true for *Salmonella* or *E. coli* pathogens.
- Different surfaces represent different challenges when you attempt to treat them with sanitizers. Given my earlier comments about the differential composition of fruit and vegetable surfaces and their microstructure, this really isn't surprising. So the skin of a tomato represents a certain level smoothness or correspondingly, niches for pathogens to shelter in and the chemical composition of the surface waxes and other constituents presents a degree of hydrophobicity that can repel water and any sanitizer that might be dissolved in that water. By contrast, the surface of a cantaloupe, green onion or spinach leaf represent completely different topographies and chemistries. Therefore, a preparing a single formulation for a sanitizer in a consumer wash product is a daunting task.
- Each of the studies I reviewed all suffered from the same problem; they rely on inoculation studies where a number of fruits or vegetables are inoculated with a prepared mixture of selected human pathogens, permitted to dry for 60-90 minutes and then washed with one of the sanitizers to evacuated how effective that sanitizer is in killing the pathogens. The problem is one of the physiology of a rapidly growing inoculum of a target pathogen prepared in a lab and placed on a fruit surface versus a natural contamination during production and the physiological state of that pathogen and how it might differentially react to a sanitizer. The physiological state of the lab-prepared bacterium would be expected to be vastly different from one that might have resided on the surface of the fruit in a field, exposed to sun and wind for some period of time, survived an initial wash in a commercial packing house, then underwent cooling and one to two weeks in transport and storage at retail and then at a consumer's home. These "in-production" pathogen contaminates have largely gone into a dormant state where they shut down much of their metabolism to preserve themselves and they are protected by biofilms. Comparing the effective kill of sanitizer treatments on active pathogens that have been placed on a surface in a laboratory with those transferred by a natural contamination event seems doubtful to me. Recent research has shown that inoculum preparation is critical in these types of experiments and the susceptibility of pathogens to many sanitizers can be variable based on the physiological state of the pathogen, and in some cases, even resistant to certain sanitizers.
- Lastly, in a couple of the studies I reviewed, washing vigorously with running water containing no sanitizer was sometimes as effective as washing with water that contained a sanitizer. Often the efficacy was improved if the water or water plus sanitizer treatments were supplemented with rubbing or scrubbing the surface. This makes sense given our discussion so far; rubbing or scrubbing would be expected to dislodge pathogens that were adhered to the surface where either the sanitizer could kill them or the running water would carry them away. However, in no paper that I reviewed did I see any treatment where pathogens were totally eliminated from the fruit or vegetable samples they were inoculated onto.

To complete this question, the conundrum developers of consumer fruit or veggie sanitizers have is to find a chemical or physical treatment that is effective in eliminating pathogens, is easy for consumers to use, can be accomplished without complicated equipment and is safe for consumers to use. For example, commercial wash water sanitizers like chlorine and ozone can be very effective in disinfecting wash water and perhaps removing 1-2 logs of surface microorganisms when administered and controlled by professionals with proper equipment and training. But in the hands of a consumer without proper training or monitoring equipment, one might expect to get off-gassing of free chlorine or ozone which can be harmful if breathed in.

Q: [Mary] - In 1997 there was a Scientific Advisory Panel convened by the Environmental Protection Agency. Scientific Advisory Panel: Fresh Fruit and Produce Sanitizing Wash. Can you give your take on the findings of the Scientific Advisory Panel on the question of household fruit and vegetable washes?

A: [Bob Whitaker] - 1997 EPA Advisory Panel Findings. The 1997 EPA Advisory Panel basically raises the same challenges I just reviewed. For background, the EPA has the responsibility for registering anti-microbial pesticide products; and, yes, an in-home fruit or vegetable sanitizer would be considered a microbial pesticide!

The EPA has well-established methodologies for testing sanitizers on hard food contact surfaces; the problem is they do not have a scientifically valid method for testing sanitizers on biological or porous surfaces. The test method would have to include many of the factors we have already discussed today like procedures for doing inoculation studies, concentrations of test pathogens, which pathogens to use, temperatures, numbers of samples and replicates of samples, etc. Further, for food contact sanitizers, the performance metric as identified by the AOAC is a 99.999% or a 5-log reduction in the number of each test organism versus the control in 30 seconds. And remember, the thought is that the treatment needs to be a single activity, like a spray or a soak, that a consumer can do easily, safely and reliably in their home.

So this all presents EPA with some tough questions related to fresh produce sanitizers: (1) Can fruits and vegetables be effectively sanitized to current EPA standards by present chemical treatment methods; and (2) if not, is the EPA and/or the scientific community willing to accept lowered performance standards for sanitization of produce?

Specifically, proposed in-home consumer produce sanitizers may involve a major change in the way we think about sanitizer application; switching from a two-step process to a single step process. The usual procedure for equipment or hard surfaces involves a two-step (pre-cleaning followed by sanitization) application. Application to fruits and vegetables involves a one step process (no pre-cleaning) to surfaces that vary tremendously (e.g., in surface area, dimension, type, consistency, texture). In addition, alternate means of application have been proposed for these products, but whether chemical applications by immersion, flooding, or spraying can achieve a "sanitization" effect, especially under homeowner conditions, is debatable. Further, a proposal for lowered performance standards (e.g. sanitation, disinfection and sterilization), if made, is a major change from recognized and scientifically accepted procedures which have been around for decades.

EPA has asked for more research on these questions and we have seen various efforts to begin to define fresh produce sanitizer efficacy. Harris et.al. published a method for testing sanitizers on fresh tomatoes in 2001. But I am not aware that any single methodology has been defined for all of the reasons we have already discussed today. Development of universal consumer wash treatments remains an elusive objective and it will be interesting to see how emerging technologies might be applied to this problem going forward.

Q: [Mary] Dr. Whitaker, thank you so much for your input on this topic. In just a minute we will start taking questions. Let’s finish up with your thoughts on the evidence about whether consumers are actually washing their produce at home properly?

A: [Bob Whitaker] – Do Consumers Wash Produce Correctly? The USDA asked the question:
To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable FS outcomes? (http://www.nel.gov/evidence.cfm?evidence_summary_id=250346)

It seems like everybody has their own approach. I can tell you in my own home between myself and my wife and my two daughters, the techniques are amazingly different.

However, in a 2007 study, Dharod et al found that among Puerto Rican home meal preparers, 87% washed their lettuce and 85% washed their tomatoes under running water while preparing salad. In their direct observation study among 99 US college students in 2004, Anderson et al, found that six did not clean any of the vegetables used to prepare a salad, 70 rinsed the lettuce, 93 rinsed the tomato, 47 rinsed the carrots and 55 rinsed the cucumber with water. This study also documented that average washing time ranged from 4.8 to 12.4 seconds, substantially shorter than the time recommended by Kilonzo-Nthenge inn 2006 where they demonstrated that washing certain fresh produce under cold running tap water with rubbing and brushing for 60 seconds reduced surface bacterial contamination. These findings indicate that washing practices can vary significantly for different vegetables and that these behaviors need to be substantially improved; certainly a formidable task.