

producesafetyalliance.cornell.edu/

# Sanitizers: Chemistry, Effectiveness, Labels

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# Topics

- Sanitizer chemistry
- Regulatory aspects
  - Water change schedule
  - Organic build up
  - Infiltration
- Effectiveness
  - Prevention of cross-contamination
  - Imperfect 'cleaning'
- EPA Labels



# Chemistries



#### Chemistries

In wash water

- Oxidizers like hypochlorite, peroxide
- Organic acids like lactic acid

On food contact surfaces

- Can be the same as in wash water
- Quaternary ammoniums like sodium dodecylbenzene sulfonate

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		Sanitizer Active Ingredients									
Product Name	Alternative Brand Names	Oxidizers	Strength (percent) 👻	Organic Acid	Strength (percent) 👻	Quaternary Ammoniums 👻	Strength (percent) 👻	Enhancers 👻	Strength (percent) 👻		
Pro-san L	N/A	None	NA	Citric acid	0.7%	Sodium dodecylbenzene- sulfonate	0.0%	None	NA		
Puma	Concentrated Clorox Germicidal Bleach1	Sodium hypochlorite	8.3%	None	NA	None	NA	None	NA		
Pure Bright Germicidal Ultra Bleach	Hi-Lex Ultra Bleach Red Max Germicidal Bleach	Sodium hypochlorite	6.0%	None	NA	None	NA	None	NA		
Re-Ox	Re-Ox Deposit Control Disinfectant Clearitas 350	Sodium hypochlorite	0.1%	None	NA	None	NA	None	NA		
SaniDate 12.0	N/A	PAA with	12.0%	None	NA	None	NA	None	NA		
				C							



## **Sodium Hypochlorite Chemistry**

- HOCl is the active form; OCl has no effectiveness
  - Above pH ~7.5, little in active form
  - Below pH ~5, unacceptable risk of poisonous Cl<sub>2</sub>





## **Peroxyacetic Acid Chemistry**

• Supplied as a corrosive mixture with an irritating, vinegar-like smell



 The hydrogen peroxide breaks down to water and oxygen, driving the equation to the right with only acetic acid and oxygen as end products

Source: J. Fisher, 1993. Cleaning Procedures in the Factory/ Types of Disinfectant *In* Encyclopaedia of Food Science, Food Technology, and Food Nutrition



## **Quaternary Ammonium Chemistry**

- Non-oxidizing activity, disrupt membranes
  - Less effective against spores, non-enveloped virus
- May be inhibited by hardness
- Most active at neutral pH
  - Range 3.0-10
- Generalized structure
  - One Nitrogen
  - Four organic chains
  - One halide or sulfate



Source: J. Fisher, 1993. Cleaning Procedures in the Factory/ Types of Disinfectant In Encyclopaedia of Food Science, Food Technology, and Food Nutrition



# **Regulatory Aspects**



#### **Model Food Code**

- Washing or cooling is NOT required for produce that is a raw agricultural commodity (RAC)
  - Model food code 2017 requires sanitizing food contact surfaces but does not require washing produce unless it is offered in READY-TO-EAT form
  - RAC are not subject to Time/Temperature controls



# **FSMA Produce Safety Rule: Postharvest Water**

#### §112.48 What measures must I take for water that I use during harvest, packing, and holding activities for covered produce?

(a) You my st manage the water as necessary, including by establishing and following water-change schedules for re-circulated in its safety and adequate sanitary quality and minimize the potential for contamination of covered produce and water, to/m food contact es with known or reasonably foreseeable hazards (for example, hazards that may be introduced into the water from soil adhering to head

of water that you use during harvest, packing, and holding activities for covered produce (b) You must visually monito (for example, water used for vashing of variable of dump tanks, flumes, or wash tanks, and water used for cooling covered produce in hydrocoolers) for buildup of organication (such as soil and plant debris). Such as soil and plant debris).

(c) You must maintain and monitor the temperatur operation (considering the time and depth of submersion) and i uate to minimize the potential for infiltration of

#### site of public health significance into covered processing of public health significance into covered water oduce does not meet the requirements of §112.41

(1) Apply a time interval(s) (in days) and/or a (calculated) log reduction by:

(ii) Applying a time interval between harvest and end of storage using an appropriate microbial die-off rate between harvest and end of storage, and/or applying a (calculated) log reduction using appropriate microbial removal rates during activities such as commercial washing, to meet the microbial quality criteria in §112.44(b) (or any alternative microbial criteria, if applicable), and any accompanying maximum time interval or log reduction, provided you have adequate supporting scientific data and information;



## **FSMA Produce Safety Rule**

§112.48 What measures must I take for water that I use during harvest, packing, and holding activities for covered produce?

#### **Compliance Dates Extended**

- Not required for farms selling less than about \$27K produce
- Compliance date January 2024 for farms selling <\$250K produce</li>
- Compliance date January 2023 for farms selling <\$500K produce
- Compliance date January 2022 for farms selling >\$500K produce

All provisions in 112.41 through 112.50 related to Agricultural Water, other than sprouts, are under re-evaluation by FDA and may be modified before compliance dates

(ii) Applying a time interval between harvest and end of storage using an appropriate microbial die-off rate between harvest and end of storage, and/or applying a (calculated) log reduction using appropriate microbial removal rates during activities such as commercial washing, to meet the microbial quality criteria in §112.44(b) (or any alternative microbial criteria, if applicable), and any accompanying maximum time interval or log reduction, provided you have adequate supporting scientific data and information;



## **Specific Elements in PSR**

# §112.48 What measures must I take for water that I use during harvest, packing, and holding activities for covered produce?

(a) You must manage the water as necessary, including by **establishing and following water-change schedules** for re-circulated water, to **maintain its safety and adequate sanitary quality** and minimize the potential for contamination of covered produce and food contact surfaces ....

(b) You must visually monitor the quality of water that you use during harvest, packing, and holding activities for covered produce ... for buildup of organic material (such as soil and plant debris).

(c) You must maintain and monitor the temperature of water at a temperature that is appropriate for the commodity and operation (considering the time and depth of submersion) and is adequate to minimize the potential for infiltration of microorganisms of public health significance into covered produce.



## Water Change Schedule

- Required under Produce Safety Rule for recirculated water
- A good idea for batch/dunk tank water
- Many strategies, but little data about pathogens to support an evidence- or risk-based schedule
  - Time (every shift, every day, weekly)
  - Volume (every X number of loads)
  - Chemical monitoring (when active ingredient fluctuates)
  - Visual monitoring (e.g., turbidity)



# **Build up of Organic Material**

- Buildup of organic material can affect sanitizer effectiveness, especially hypochlorite (bleach)
- Organic material adds turbidity to water
  - Lettuce 'latex'
  - Other oozes
  - Shows up as chemical oxygen demand (COD)

Luo et al., 2014 Chapter 7 in *Global Safety of Fresh Produce*. pp 103-111





#### **Measuring Turbidity**

- Cheap way: Eyeball how dirty the water is
  - Hard to write into an SOP
- Pricey way: Buy a turbidometer
- Useful way: DIY Secchi turbidity measurement SOP

EDISODE 043

300 NTU

3000 NTU



#### Handling Turbidity in Postharvest Wash Water

Turbidity in postharvest wash water is one of three major factors that need to be monitored to ensure effectiveness of sanitizer in wash water. Along with the wrong pH and inadequate free sani-

Tocco 2016 Michigan State Extension AFSM043-01



#### **Temperature and Infiltration**

• Excerpt from a Joint Institute for Food Safety and Applied Nutrition (JIFSAN) presentation



Source: Postharvest Biology and Technology. 2016. 118:159-174



# **Effectiveness Data**



## **Effectiveness of Washing**

- Pilot scale wash processes, with and without sanitizer and detergent, show a wide range (about 1-2 log) effectiveness
  - Recommended to prevent cross-contamination
  - Not recommended to decontaminate product because harborage areas and biofilms limit effectiveness



## **Sodium Hypochlorite Data**

- Commodities: Iceberg lettuce
- Sanitizer: Sodium hypochlorite (bleach; 50 ppm)
- Other treatments: With and without acidification (pH 7.85 or to 6.5 with citrate/T-128), organic load (macerated lettuce)
- Target organisms: *E. coli* O157:H7

Journal of Food Protection, Vol. 77, No. 10, 2014, Pages 1669–1681 doi:10.4315/0362-028X.JFP-14-067 Copyright ©, International Association for Food Protection

Impact of Organic Load on *Escherichia coli* O157:H7 Survival during Pilot-Scale Processing of Iceberg Lettuce with Acidified Sodium Hypochlorite

GORDON R. DAVIDSON, † CHELSEA N. KAMINSKI, ‡ AND ELLIOT T. RYSER\*

## **Sodium Hypochlorite**

#### Davidson et al., 2014 JFP 77:1669-1681

~4 to 5-log reduction in water 1 to 2 log reduction on product

TABLE 2. E. coli O157:H7 reductions in flume water<sup>a</sup>

		<i>E. coli</i> O157:H7 reduction in flume water (mean log CFU/ml $\pm$ SD)							
Sanitizing treatment	% organic load (wt/vol)	0 min	21 min	44 min					
Chlorine	0	5.2 ± 1.1 A	$5.5 \pm 0.5$ a	5.4 ± 0.5 a					
	2.5	0.2 ± 0.3 в	2.3 ± 0.6 в	$3.9 \pm 0.9$ A					
	5	0.3 ± 0.2 в	$0.8~\pm~0.4~\mathrm{c}$	1.6 ± 0.7 в					
	10	0.1 + 0.2 в	$0.5 \pm 0.2 \text{ c}$	0.9 ± 0.3 в					
Chlorine + CA	0	5.8 ± 0.1 a	$5.6 \pm 0.6$ A	$5.9 \pm 0.0$ A					
	2.5	0.2 ± 0.0 в	4.9 ± 0.3 AB	$5.2 \pm 0.1$ Ab					
	5	0.2 ± 0.4 в	4.3 ± 0.4 AB	4.7 + 0.7 AB					
	10	0.0 + 0.1 в	3.3 ± 1.4 в	4.0 ± 1.2 в					
Chlorine + T-128	0	5.6 ± 0.5 a	$5.7 \pm 0.5$ A	$5.9 \pm 0.0$ A					
	2.5	0.0 ± 0.2 в	$4.6 \pm 0.7$ A	4.8 + 0.6 AB					
	5	0.2 ± 0.1 в	2.9 ± 0.4 в	4.2 ± 1.1 ав					
	10	$0.2 \pm 0.5$ в	2.3 ± 0.2 в	3.9 ± 0.4 в					

<sup>*a*</sup> Means with different letters designate *E. coli* O157:H7 reductions that differ significantly in terms of sanitizing treatment and time (P < 0.05).

Note that some pathogen always remains. There are no "greater than" results



# Peroxyacetic Acid (PAA) Data

- Commodity: Iceberg lettuce
- Sanitizer: Peroxyacetic acid (and mixes; 50 ppm)
- Other treatments: With and without organic load (macerated lettuce)
- Target organisms: *E. coli* O157:H7



International Journal of Food Microbiology

Volume 248, 2 May 2017, Pages 22-31



Persistence of *Escherichia coli* O157:H7 during pilot-scale processing of iceberg lettuce using flume water containing peroxyacetic acid-based sanitizers and various organic loads

produce Gordon R. Davidson, Chelsea N. Kaminski-Davidson, Elliot T. Ryser 🐣 🖾

# Peroxyacetic Acid (PAA)

Davidson et al., 2017 Int. J. Food Micro. 248:22-31

~5-log reduction in water 1-2 log reduction on product

#### Table 2

*E. coli* O157:H7 reduction in flume water containing organic load and 50 ppm peroxyacetic acid or 50

	Mean $\pm$ SD <i>E. coli</i> O157:H7 reduction in flume water (log CFU/ml)						
	0 min	21 min	44 min				
)	$3.59\pm0.18~\text{A}$	$5.85 \pm 0.15$ A	$5.92\pm0.02$ A				
2.5	$3.56\pm0.36\text{A}$	$5.77 \pm 0.13$ A	$5.75\pm0.09\mathrm{A}$				
5	$2.93\pm0.38~\text{A}$	$5.25 \pm 0.04$ B	$5.25\pm0.02~\mathrm{B}$				
10	$3.48\pm0.08~\text{A}$	$5.25 \pm 0.02 \text{ B}$	$5.18\pm0.10~\text{B}$				
)	$4.08 \pm 0.77 \text{ A}$	$5.85 \pm 0.15$ A	$5.92\pm0.02~\text{A}$				
2.5	$4.98\pm0.30~\text{A}$	$5.59 \pm 0.19$ A	$5.62\pm0.15$ B				
5	$3.93 \pm 1.47 \text{ A}$	$5.25 \pm 0.03 \text{ B}$	$5.25\pm0.02$ C				
10	$4.01\pm1.34~\text{A}$	$4.95\pm0.02~\mathrm{B}$	$4.88\pm0.10~\text{D}$				
2. 5 1( 2. 5	5 0 5 0	$\begin{array}{c} 3.59 \pm 0.18 \text{ A} \\ 5 & 3.56 \pm 0.36 \text{ A} \\ 2.93 \pm 0.38 \text{ A} \\ 0 & 3.48 \pm 0.08 \text{ A} \\ 4.08 \pm 0.77 \text{ A} \\ 5 & 4.98 \pm 0.30 \text{ A} \\ 3.93 \pm 1.47 \text{ A} \\ 0 & 4.01 \pm 1.34 \text{ A} \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$				

Means with different capital letters designate E. coli O157:H7 reductions that differ significantly

Note that some pathogen always remains. There are no "greater than" results



# **EPA** Labels



#### What and Where

- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of pesticides (including 'antimicrobial pesticides')
- The EPA label, under FIFRA, must be followed
- The PSA Sanitizer spreadsheet is one place to gain access to labels

dnp274@.comell.edu, 909-552-4255).	Back to MAIN PAGE		EPA Registration Details						1		
				CPA Label			Labeled Uses				
Product Name	Alternative Brand Names	<u>Active</u> Ingredients	FPA Registration Number	Link to EPA Label	EPA Accepted Date	Labeled For Use on Non-Porous Food Contact Surfaces?	Labeled For Use in Fruit and Vegetable Wash Water <sup>2</sup>	Labeled For Use in Irrigation Water?	Contains Efficacy Statement to Control Public Health Organisms?	Organic Materials Review Institute (OMRI) Listing	Notes
Pro-san I.	N/A		71094-2	Label PDP	5,10/2017	Yes See Page 4	Yes See Page 4		For Food Contact Surfaces	Not listed	None
Pume	Concentrated Clorox Germicidal Diesch1 Clorox Germicidal Bleach2 Clorox Regular Bleach1 Clorox Multi-Purpose Diesch1 Concentrated Clorox Multi-purpose Bleach1 Clorox Disinfecting Bleach1 Concentrated Clorox Disinfecting Bleach1 Concentrated Clorox Regular-Bleach Hi-Lex Ultra Bleach		5813-100	Label PDP	) /R/2017	Yes Soc Page 15	Yes See Page 15		For Food Contact Surfaces	Not listed	None
		_P	rec	UC	e	Sa	fei	Y-			
lucesafetvalliance	cornell edu/		Α	LL	ΙΑ	NC	E				

## **Marketing Claims, Active Ingredients**

- Marketing Claims
- Bleach type sanitizer



ALLIANCE

#### **Directions for Use**

#### General statements

#### PHYSICAL OR CHEMICAL HAZARDS

**STRONG OXIDIZING AGENT:** Mix only with water, according to label directions. Mixing this product with chemicals (e.g. ammonia, acids, detergents, etc.) or organic matter (e.g. urine, feces, etc.) will release chlorine gas, which is irritating to eyes, lungs and mucous membranes.

#### DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. NOTE: This product degrades with age. Use a chlorine test kit and increase dosage, as necessary, to obtain the required level of chlorine.

Example Label: Zep



#### **Directions for Use**

#### • Use-specific statements

#### FRUIT AND VEGETABLE WASHING

This product can be used in accordance with 21 CFR 173.315 to wash fruits and vegetables. Thoroughly clean all fruits and vegetable in a wash tank. In a second tank, thoroughly mix 5 oz. of this product with up to 200 gallons of water to make a sanitizing solution. Drain wash tank. Submerge fruits or vegetables for 2 minutes in the second tank containing the recirculating sanitization solution. Spray rinse vegetables with the sanitizing solution prior to packaging. Rinse fruit with potable water only prior to packaging.

#### SANITIZATION OF SURFACES SUCH AS PROCESSING EQUIPMENT, DAIRY EQUIPMENT, FOOD UTENSILS, DISHES, SILVERWARE, GLASSES, SINK TOPS, COUNTER TOPS, REFRIGERATED STORAGE AND DISPLAY EQUIPMENT AND OTHER NON-POROUS FOOD CONTACT SURFACES IN CANNERIES, MEAT PACKING PLANTS, DAIRIES, AND OTHER FOOD INDUSTRIES

**RINSE METHOD:** A solution of 100 ppm available chorine may be used in the sanitizing solution, if a chlorine test kit is available. Solutions containing an initial concentration of 100 ppm available chlorine must be tested and adjusted periodically to insure that the available chlorine does not drop below 50 ppm. Prepare a 100 ppm sanitizing solution by thoroughly mixing 1 oz. of this product with 10 gallons of water. If no test kit is available, prepare a sanitizing solution by thoroughly mixing 2 oz. of this product with 10 gallons of water, to provide approximately 200 ppm available chlorine by weight. Clean equipment surfaces in the normal manner. Prior to use, rinse all surfaces thoroughly with the sanitizing solution, maintain contact with the sanitizer for at least 2 minutes. If solution or add sufficient product to reestablish a 200 ppm residual. Do not rinse equipment with water after treatment and do not soak equipment overnight. Sanitizers used in automated systems may be used for general cleaning but may not be reused for sanitizing purposes.

**IMMERSION METHOD:** A solution of 100 ppm available chlorine may be used in the sanitizing solution of a chlorine test kit is available. Solutions contain an initial concentration of 100 ppm available chlorine must be tested and adjusted periodically to insure that the available chlorine does not drop below 50 ppm. Prepare a 100 ppm sanitizing solution by thoroughly mixing 1 oz. of this product with 10 gallons of water. If no test kit is available, prepare a sanitizing solution by thoroughly mixing 2 oz. of this product with 10 gallons of water, to provide approximately 200 ppm available chlorine by weight. Clean equipment in the normal manner. Prior to use, immerse equipment in the sanitizing solution for at least 2 minutes and allow the sanitizer to drain. If solution contains less than 50 ppm available chlorine, as determined by a suitable test kit, either discard the solution or add sufficient product to reestablish a 200 ppm residual. Do not rinse equipment with water after treatment. Sanitizers used in automated systems may be used for general cleaning, but may not be reused for sanitizing purposes.

**Preduce Safety** 

ALLIAN<u>C</u>E

#### Example Label: Zep

#### Worker safety

#### • FIFRA requirements

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#### PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS AND DOMESTIC ANIMALS

**DANGER:** Corrosive. Causes inteversible eye damage and skin burns. May be fatal if swallowed. Do not get in eyes, on skin or on cloching. Wear goggles or safety glasses and rubber gloves when handling this product. Irritating to nose and throat. Avoid breathing dust. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse. Avoid breathing vapors. Vacate poorly ventilated area as soon as possible. Do not return until strong odors have dissipated.

#### FIRST AID

**IF IN EYES:** Hold eye open & rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then, continue rinsing eye. Call a poison control center or doctor for treatment advice.

IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

IF SWALLOWED: Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then, give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-541-2016 for emergency medical treatment information.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

Example Label: Zep



#### **Storage and Disposal**

#### • Also FIFRA requirements

#### STORAGE AND DISPOSAL

DO NOT CONTAMINATE WATER, FOOD, OR FEED BY STORAGE OR DISPOSAL. **PESTICIDE STORAGE**: Store this product in a cool, dry area, away from direct sunlight and heat to avoid

deterioration. In case of spill, flood areas with water.

**PESTICIDE DISPOSAL:** Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

**CONTAINER DISPOSAL**: Nonrefillable container. Do not reuse or refill this container. Offer for recycling, if available. Clean container promptly after emptying.

(Note to reviewer. If container sizes is equal to or less than 5 gallons, the following statement will be used.) Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank and store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

(Note to reviewer. If container sizes is greater than 5 gallons, the following statement will be used.)

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank and store rinsate for later use or disposal. Repeat this procedure two more times.

Example Label: Zep



# Conclusions

- Washing produce can introduce hazards to the safety of produce
- Produce Safety Rule will impose requirements
  - Farms must maintain quality of water during use
  - Farms must reduce risk of infiltration
- Postharvest cooling/washing has risks and benefits for produce shelf life and overall safety
  - Disinfection is not possible (some pathogens always remain; no study shows, e.g., 5-log removal)
- The EPA label is a source of scientific and regulatory information

