Antimicrobial Spray Treatments for Red Meat Carcasses Processed in Very Small Meat Establishments

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Background and Purpose

Very small meat establishments throughout the United States are required to implement a Hazard Analysis and Critical Control Point (HACCP) plan. These establishments often rely on scientific studies to validate their HACCP plans. However, most of these studies simulate the conditions found in large establishments. Limited space, manpower, and financial resources often make it difficult or impossible to implement certain antimicrobial interventions (for example, automated washing cabinets, steam pasteurization, and steam vacuuming) in very small plants. With financial support from the USDA, The Pennsylvania State University worked with Texas Tech University and Washington State University to generate new data that very small establishments can use to effectively remove pathogens from carcass surfaces.

Casting aside time-honored techniques to do things in a new way is a challenge. Because food safety is everyone’s responsibility, the meat processor should be willing to consider improvements to food safety during slaughter. In particular, the approach to carcass washing can become more precise and science-based.

Just like the sanitation of food contact surfaces, effective carcass washing is a multi-step process. The carcass surface must be cleaned before it can be sanitized. The following information describes an effective antimicrobial intervention for red meat carcasses processed in very small meat plants. After performing this intervention, carcasses can be moved into the hotbox or chill cooler before fabrication and further processing.

Step 1. Water Wash

This first step emphasizes effective cleaning of carcass surfaces with a warm water wash.

- ✓ Observe the surface of the carcass during washing to ensure that hair, blood and other obvious debris are adequately removed. Failure to remove any visible contamination may interfere with the final sanitizing step.

- ✓ Wash each side of beef with warm water for at least 2 minutes. Smaller carcasses like lamb, pork, veal, or goat should be washed for at least 1 minute.

- ✓ In plants with low ceilings, beef sides may be cut into quarters. Each pair of quarters should be washed for 2 minutes with warm water.

- ✓ It is also important to wash the carcass from top to bottom. This way you will work with gravity to wash bacteria and foreign matter down the carcass and towards the floor and you will not cross-contaminate other parts of the carcass.

- ✓ Be careful not to spray water directly on the floor since bacteria could be splashed back onto the carcass. Similarly, be aware of the spray mist that is often produced during washing. Try to avoid spraying debris from one carcass onto another.

- ✓ It is suggested that only one carcass be washed at a time. In this way, a worker can give each carcass the full attention that it needs.

- ✓ The goal is to remove contaminants from each carcass individually, but in such a way that minimizes the cross contamination of other carcasses.

Some physical factors to consider during spray washing include the distance between the hose nozzle and the carcass surface, water temperature, water pressure, and the amount of time spent washing.

Distance

Research has demonstrated that workers should hold the nozzle <u>no more</u> than one foot from the carcass surface.

If hot or warm water is used, the water temperature is better maintained when the nozzle is <u>no more</u> than 12 inches from the carcass surface because less heat is lost as the water travels through the air.

Temperature

In general, hot water is more effective at removing bacteria than warm or cold water.

Hot water may discolor muscle tissue that is exposed on carcass surfaces. Therefore, consider using warm water if hot water is not used to wash carcasses.

Washing carcasses with cold water does remove bacteria by virtue of physical force; yet, it does very little to injure or kill bacteria that may remain on carcass surfaces.

Pressure

The water stream is most forceful at the opening of the hose nozzle. The water loses momentum the further it has to travel.

As with temperature, it is a good idea to keep the nozzle no more than 12 inches from the carcass surface.

Time

In general, research has demonstrated that the more time that is spent washing a carcass, the cleaner it will be. Washing the carcass for a longer period of time allows the force of the water to detach more bacteria and debris.

Cost comparison of hot, warm and cold water

The washing of carcasses with hot or warm water is more effective at eliminating bacterial loads than using cold water. The following analysis provides a comparison of the cost of water used at hot, warm, and cold temperatures. To simplify this analysis, several assumptions have been made (Table 1). The cost of water per gallon and per carcass is presented in Table 2.

Table 1. Cost comparison assumptions

Cost comparison factor	Assumption
Federal average electricity price in the United States[1]	$0.06/kWh
Average cost of tap water in the United States[2]	$0.0005/L ($0.002/gal)
Efficiency of water heating system[3]	100%
Water flow rate[4]	10 gpm

[1]Energy Cost Calculator for Commercial Boilers (Closed Loop, Space Heating Applications Only). September 29, 2004. Federal Energy Management Program, Energy Efficiency and Renewable Energy, U. S. Department of Energy http://www.eere.energy.gov/femp/technologies/eep_boilers_calc.cfm accessed: June 8, 2005

[2] Safe Drinking Water Act 30th Anniversary Drinking Water Costs & Federal Funding. June 2004. U. S. Environmental Protection Agency http://www.epa.gov/safewater/sdwa/30th/factsheets/costs_funding.html accessed: June 9, 2005

[3] Generally, heating systems are not 100% efficient. Efficiency varies greatly by heater type and energy source.

[4] Water flow rates can vary by spray gun model, water supply, and the squeezing of the trigger.

Table 2. Cost comparison of cold, warm and hot water on per gallon and per carcass bases

Water temperature	Cost per gallon[1]	Cost per carcass (small red meat)[2]	Cost per carcass[3] (beef)
Cold (15.6°C, 60°F)	$0.002[4]	$0.02	$0.08
Warm (54.4°C,130°F)	$0.005	$0.05	$0.20
Hot (82.2°C,180°F)	$0.007	$0.07	$0.28

[1] Energy (kWh) needed to heat water =

$$\frac{\text{Water (L)}}{1{,}000} \times \frac{4.187\ \text{kJ}}{\text{kg}\cdot{}^{\circ}\text{C}} \times \text{Water temp. rise}({}^{\circ}\text{C}) \times \frac{100}{\%\ \text{efficiency}} \times \frac{1\text{kWh}}{3.6\ \text{MJ}}.$$

The amount of energy needed to heat water is multiplied by the Federal average electricity price and then added to the average cost of tap water.

[2] Small red meat carcasses are pork, lamb, veal, and goat. These carcasses should be washed for at least one minute. At a flow rate of 10 gpm (Table 1), a smaller red meat carcass is washed with 10 gal of water.

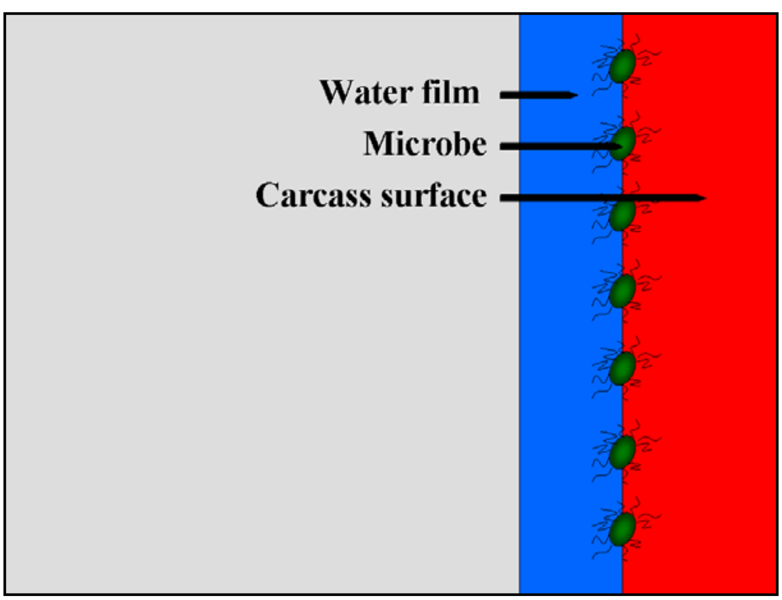
[3] Each side of beef should be washed with water for at least two minutes. An entire beef carcass should be washed with water for at least four minutes. At a flow rate of 10 gpm, a beef carcass is washed with 40 gal of water.

[4] Washing carcasses with cold water directly from the tap does not require heating. Therefore, the cost per gallon of cold water equals the average cost of tap water in the U. S.

Step 2. Five-Minute Drip

Allowing the carcass to drip for five minutes after washing is an important step.

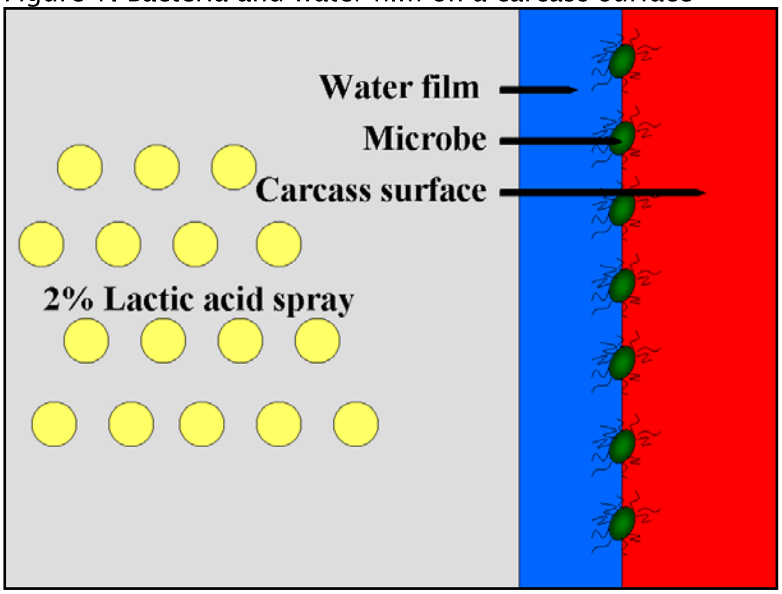
- ✓ Allow excess water to drip from the carcass for at least 5 minutes.
- ✓ This step ensures that the antimicrobial rinse (2% lactic acid) makes better contact with bacteria on the carcass surface.
- ✓ Carcasses should be spaced to avoid coming in contact with each other, nearby walls, and other surfaces.



Harmful bacteria like *E. coli* O157:H7, *Salmonella* spp. and *Campylobacter* spp. may still be present on meat surfaces after washing with warm water (Figure 1).

Immediately after washing, a water film is present on the carcass surface. So, the carcass must be given time to allow the water film to dissipate.

Figure 1. Bacteria and water film on a carcass surface



If the carcass is not given adequate time to drip, then the excess water film could dilute the acid and make it less effective (Figures 2 and 3). The excess water film can make it more challenging to eliminate harmful bacteria.

Figure 2. 2% Lactic acid rinse being applied to a carcass surface that has not been allowed to drip adequately

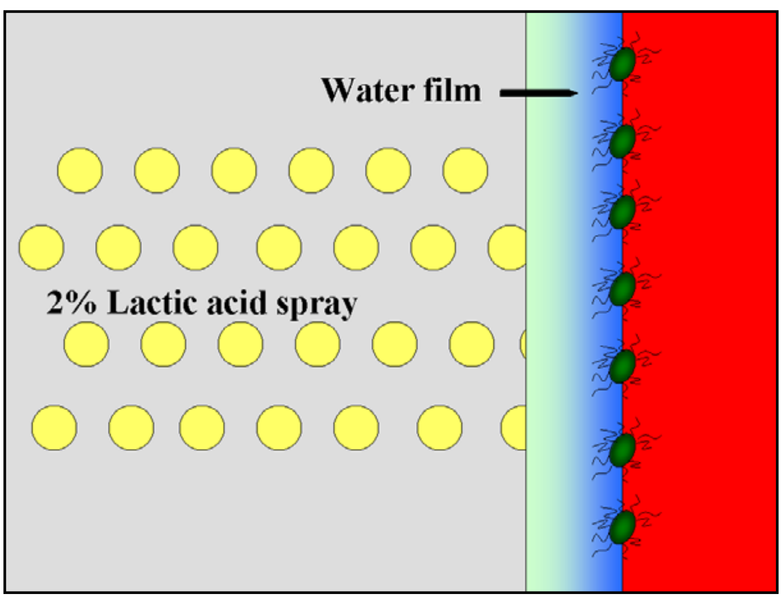


Figure 3. 2% Lactic acid is diluted as it mixes with the water film on a carcass surface.

Step 3. Antimicrobial Rinse

After five minutes of drip time, spray the carcass with 2% lactic acid.

- ✓ Rinse the carcass with enough 2% lactic acid to cover the carcass completely. Sufficient lactic acid should be sprayed on the carcass such that some of it drips off.
- ✓ Try to keep the spray nozzle within 12 inches of the carcass surface.
- ✓ Use a gentle sweeping motion to apply the lactic acid to the entire carcass surface.
- ✓ Work methodically from top to bottom to ensure that all carcass surfaces are treated with lactic acid.
- ✓ A side of beef should be rinsed with 2% lactic acid for at least <u>1 minute</u>. Other red meat carcasses (lamb, pork, veal, and goat) should be rinsed for at least <u>30 seconds</u>.
- ✓ If beef sides are divided into quarters, rinse each pair of quarters for 1 minute.
- ✓ At this point, the carcass is ready to be moved into the hotbox or chill cooler.

Rationale for Using Lactic Acid as a Carcass Sanitizer

Several food-safe compounds were tested at Penn State to determine antimicrobial effectiveness and feasibility in a pilot plant setting. Organic acids (lactic, acetic, and citric), peroxyacetic acid, chlorine-based compounds (acidified sodium chlorite, chlorine dioxide, sodium hypochlorite), and ozonated water were applied to inoculated beef surfaces. Populations of *E. coli* O157:H7, *Salmonella* Typhimurium, *Campylobacter* spp., mesophilic aerobic plate count, coliforms, and generic *E. coli* before treatment and after treatment were measured and log reductions calculated.

Lactic, acetic, and citric acids were more effective at the broad-spectrum decontamination of beef surfaces than the other compounds tested (Tables 3 and 4). Of these three organic acids, lactic acid seemed to be the most user friendly because it has a pleasant odor and is less irritating to the skin than acetic or citric acid.

Tips for the Safe Handling of Lactic Acid

Read the Material Safety Data Sheet and keep it in an accessible place in case of an emergency.

Wear gloves, goggles and apron or frock when handling and applying acid since it is corrosive and can cause serious chemical burns on the skin or in the eyes.

Store concentrated acid in its original bottle and as directed by the Material Safety Data Sheet. If the acid is shipped in glass containers, be sure to keep them far away from meat processing rooms. Broken glass can create a serious physical hazard.

Prepare, hold and store 2% lactic acid solution in clearly labeled plastic containers. These containers should be thoroughly washed and air-dried after use.

Table 3. Antimicrobial effectiveness of several food-safe compounds used to eliminate meatborne pathogens from experimentally inoculated beef surfaces

Antimicrobial rinses	*Escherichia coli* O157:H7			*Salmonella* Typhimurium			*Campylobacter* spp.		
	Before treatment[a]	After treatment	Log reduction	Before treatment	After treatment	Log reduction	Before treatment	After treatment	Log reduction
Ozonated water 15 sec	6.75	4.52	2.23	7.40	4.54	2.86	4.98	3.54	1.44
Ozonated water 30 sec	7.31	4.70	2.61	7.28	4.97	2.31	4.98	2.99	1.99
Tap water 15 sec[b]	6.31	4.85	1.46	6.99	5.04	1.95	4.65	3.56	1.09
Tap water 30 sec	6.48	5.40	1.08	7.34	5.42	1.92	5.02	3.23	1.79
Bleach 100 ppm	5.27	3.83	1.44	5.47	3.43	2.04	4.16	2.28	1.88
Bleach 600 ppm	4.30	2.53	1.77	5.80	3.83	1.97	4.92	2.74	2.18
Chlorine dioxide 100 ppm	4.62	2.67	1.94	5.55	3.39	2.16	5.09	1.68	3.41
Chlorine dioxide 540 ppm	5.45	2.40	3.05	5.65	2.86	2.78	4.84	0.47	4.37
Acidified sodium chlorite 500 ppm	5.54	2.14	3.40	5.79	2.67	3.12	5.48	1.68	3.80
Acidified sodium chlorite 1,200 ppm	3.71	0.00	3.71	5.86	2.54	3.32	3.62	1.44	2.18

Antimicrobial rinses (continued)	*Escherichia coli* O157:H7			*Salmonella* Typhimurium			*Campylobacter* spp.		
	Before treatment[a]	After treatment	Log reduction	Before treatment	After treatment	Log reduction	Before treatment	After treatment	Log reduction
Peroxyacetic acid 200 ppm	4.40	3.96	0.44	5.18	4.15	1.03	6.09	2.83	3.26
Peroxyacetic acid 1,000 ppm	4.48	0.70	3.78	5.86	1.11	4.75	5.28	1.17	4.11
Citric acid 1%	5.18	1.91	3.27	5.62	2.50	3.12	4.13	0.74	3.39
Citric acid 2%	5.24	1.64	3.60	6.78	2.93	3.85	5.28	0.70	4.69
Citric acid 5%	6.40	2.68	3.72	6.37	1.82	4.55	4.95	0.90	4.05
Acetic acid 1%	3.52	1.36	2.16	5.61	3.06	2.55	5.28	0.70	4.58
Acetic acid 2%	5.60	0.37	5.23	5.40	2.02	3.38	5.57	0.47	5.10
Acetic acid 5%	5.18	2.76	2.42	5.71	0.95	4.76	4.55	0.47	4.08
Lactic acid 1%	5.59	2.69	2.90	5.65	2.08	3.57	5.35	1.44	3.91
Lactic acid 2%	4.03	0.48	3.55	5.48	0.70	4.78	7.15	2.14	5.01
Lactic acid 5%	5.82	0.50	5.32	5.81	0.93	4.88	5.52	0.55	4.97
Purified water[c]	5.48	4.25	1.23	5.89	4.56	1.33	5.01	3.62	1.38

[a]For each antimicrobial rinse, the average populations of bacteria before and after rinsing are presented and the log reductions calculated by: Before treatment – After treatment = Log reduction.

[b]Tap water flowed through a portable ozone generator without ozonation for 15 or 30 sec to provide a control for 15 or 30 sec ozonated water rinses.

[c]Water was purified by reverse osmosis and used as a control for all antimicrobial rinses except ozonated water.

Table 4. Antimicrobial effectiveness of several food-safe compounds used to eliminate hygiene indicators from experimentally inoculated beef surfaces

Antimicrobial rinses	Mesophilic aerobic plate count			Coliforms			Generic *E. coli*		
	Before treatment[a]	After treatment	Log reduction	Before treatment	After treatment	Log reduction	Before treatment	After treatment	Log reduction
Ozonated water 15 sec	9.42	9.40	0.02	9.05	8.97	0.08	7.87	6.98	0.89
Ozonated water 30 sec	9.85	9.62	0.23	9.28	9.11	0.17	7.47	7.36	0.11
Tap water 15 sec[b]	9.72	9.07	0.65	9.17	8.78	0.39	7.26	6.60	0.66
Tap water 30 sec	9.71	9.27	0.44	9.27	8.97	0.30	6.74	6.77	−0.03
Bleach 100 ppm	9.36	7.15	2.21	9.07	6.69	2.38	5.82	3.41	2.41
Bleach 600 ppm	9.67	8.31	1.36	9.38	8.00	1.38	0.00[d]	0.00	0.00
Chlorine dioxide 100 ppm	8.58	5.88	2.70	7.96	4.94	3.02	5.40	3.07	2.33
Chlorine dioxide 540 ppm	9.43	4.62	4.81	8.17	3.65	4.52	0.00[d]	0.00	0.00
Acidified sodium chlorite 500 ppm	8.68	4.97	3.71	8.18	3.74	4.44	0.00[d]	0.00	0.00
Acidified sodium chlorite 1,200 ppm	8.61	5.87	2.74	8.15	3.50	4.65	0.00[d]	0.00	0.00

Antimicrobial rinses (continued)	Mesophilic aerobic plate count			Coliforms			Generic *E. coli*		
	Before treatment[a]	After treatment	Log reduction	Before treatment	After treatment	Log reduction	Before treatment	After treatment	Log reduction
Peroxyacetic acid 200 ppm	9.17	7.65	1.52	8.41	5.75	2.66	6.51	4.13	2.38
Peroxyacetic acid 1,000 ppm	8.66	4.84	3.82	8.10	3.38	4.72	5.60	0.85	4.75
Citric acid 1%	9.61	5.69	3.92	9.29	4.98	4.31	6.95	3.43	3.52
Citric acid 2%	9.52	6.32	3.20	9.16	3.81	5.35	6.48	2.62	3.86
Citric acid 5%	10.13	5.64	4.49	9.41	4.69	4.72	6.25	1.58	4.67
Acetic acid 1%	8.63	6.09	2.54	8.14	4.60	3.54	6.00	3.41	2.59
Acetic acid 2%	8.87	5.03	3.84	8.44	2.89	5.55	6.04	1.57	4.47
Acetic acid 5%	9.43	5.90	3.53	9.24	4.35	4.89	5.59	2.20	3.39
Lactic acid 1%	8.48	5.98	2.50	7.99	4.91	3.08	5.30	3.60	1.70
Lactic acid 2%	9.18	3.90	5.28	8.80	3.63	5.17	7.13	3.60	3.53
Lactic acid 5%	9.81	4.87	4.94	9.50	3.88	5.62	6.89	3.60	3.29
Purified water[c]	9.07	7.71	1.36	8.55	7.07	1.48	4.93	3.88	1.05

[a]For each antimicrobial rinse, the average populations of bacteria before and after rinsing are presented and the log reductions calculated by: Before treatment – After treatment = Log reduction.

[b]Tap water flowed through a portable ozone generator without ozonation for 15 or 30 sec to provide a control for 15 or 30 sec ozonated water rinses.

[c]Water was purified by reverse osmosis and used as a control for all antimicrobial rinses except ozonated water.
[d]General *E. coli* were not detected from the natural microflora of the experimental inoculum.

How to Prepare 2% Lactic Acid

Most plants purchase food grade lactic acid as a concentrated liquid because it costs less to ship it and requires less room for storage. However, proper dilution is essential to the efficacy of the acid rinse. Refer to the following formula and example (vol. = volume, conc. = concentration):

Starting Vol. × Starting Conc. = Final Vol. × Final Conc.

Example 1

John needs to prepare 10 liters of 2% lactic acid for Tuesday's kill. He has several bottles of 88% lactic acid in the store room. How much concentrated (88%) acid and tap water does he need to prepare 10 liters of 2% lactic acid?

Given:
Starting concentration = 88%
Final volume = 10 liters
Final concentration = 2%

Unknown:
Starting volume = ?

Using the formula above, John solves for the unknown starting volume.

$$\text{Starting volume (liters)} \times 88\% = 10 \text{ liters} \times 2\%$$

$$\text{Starting volume} = \frac{10 \text{ liters} \times 2\%}{88\%}$$

$$\text{Starting volume} = 20 \div 88$$

$$\text{Starting volume} = 0.23 \text{ liters concentrated acid}$$

After putting on goggles, gloves, and an apron, John needs to measure 0.23 liters of 88% lactic acid into a plastic container. Now, John needs to add enough water to make 10 liters of solution. He subtracts:

10 liters – 0.23 liters = 9.77 liters tap water

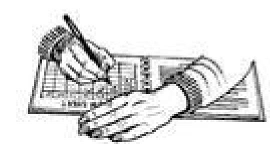
Adding 9.77 liters of tap water to the acid and mixing the solution thoroughly will give John the 10 liters of 2% lactic acid that he needs for Tuesday's kill.

Example 2

Mike's Meat Plant is receiving 13 steers from the county fair next week. He knows that he should rinse each side of beef with 2% lactic acid for at least 1 minute. His spray tank can deliver 1.5 liters of 2% lactic acid per minute. Based on this information, he needs to prepare a bare minimum of 39 liters of 2% lactic acid (13 steers X 2 sides of beef per steer X 1 minute per side X 1.5 liters acid per minute). Mike prepares 45 liters of 2% lactic acid instead of 39 liters because a new employee will be doing the rinsing.

The concentrated lactic acid that he uses is 85% pure. How much acid and water does he need to mix together and to record on his recordsheet?

Given:
Starting concentration = 85%
Final volume = 45 liters
Final concentration = 2%



Unknown:
Starting volume = ?

Using the same formula, Mike solves for the unknown starting volume.

Starting volume (liters) × 85% = 45 liters × 2%

$$\text{Starting volume} = \frac{45 \text{ liters} \times 2\%}{85\%}$$

Starting volume = 90 ÷ 85

Starting volume = 1.06 liters concentrated acid

Mike wears goggles, gloves, and an apron to pour 1.06 liters of 85% lactic acid into a large plastic bin. Now, Mike needs to add enough water to make 45 liters of solution. He subtracts:

45 liters – 1.06 liters = 43.94 liters tap water

Adding 43.94 liters of tap water to the acid and mixing the solution thoroughly will give Mike 45 liters of 2% lactic acid. He is not tempted to round off 43.94 to an even 44.00 because he knows that this mixture will not give him the 2% lactic acid solution that is dictated in his plant's HACCP plan.

Effectiveness of a 2% Lactic Acid Rinse under Laboratory Conditions

In the laboratory, a 2% lactic acid rinse was applied to experimentally inoculated beef brisket pieces for 15 seconds at 40 psi and at room temperature. This rinse treatment reduced populations of *E. coli* O157:H7, *Salmonella* Typhimurium, *Campylobacter* spp. by 3.5 to 5 log cycles (Figure 5). To clarify, one log cycle is equal to 90%. So, 3 log cycles equals 99.9% and 5 log cycles means a 99.999% reduction in bacteria. Mesophilic APCs, coliforms, and generic *E. coli* were reduced by 3.5 to over 5 log cycles.

Table 5. Average log reductions of common meat pathogens and hygiene indicators on beef surfaces*

Bacterial population	Log reduction
Escherichia coli O157:H7	3.5
Salmonella Typhimurium	4.7
Campylobacter spp.	5.0
Mesophilic aerobic plate count	5.3
Generic *E. coli*	5.2
Coliforms	3.5

*Beef surfaces were treated with a 2% lactic acid rinse applied at room temperature for 15 seconds at 40 psi (Source: Flowers, S. L. 2005. Ph.D. Dissertation. The Pennsylvania State University, University Park, PA)

Suggestions for Establishing a Critical Limit

Here are two ways to define a critical limit for this intervention, which may become a critical control point in the HACCP plan of a very small plant.

1. Specify the length of time (i.e., seconds or minutes) that the carcass will be sprayed with 2% lactic acid. Also note that enough 2% lactic acid should be sprayed onto the carcass surface so that the whole surface is dripping wet and some of it runs off.

2. Specify the volume of 2% lactic acid that will be applied to each carcass. Also note that enough 2% lactic acid should be sprayed onto the carcass surface so that the whole surface is dripping wet and some of it runs off.

Suggestions for Monitoring a Critical Limit

Here are two feasible methods for monitoring the Critical Limits suggested above.

1. Use a titration kit to measure acidity (% acid) after preparing a solution of 2% lactic acid. Follow the manufacturer's instructions closely to get a valid measurement. Record the acidity of each batch of 2% lactic acid solution on a record sheet.

2. During preparation of 2% lactic acid, measure and record the amounts (volume or weight) of water and lactic acid that are mixed together. Mixing together the correct amounts of concentrated acid and water will ensure proper preparation of 2% lactic acid.

Suggestions for Corrective Actions

If a batch of 2% lactic acid does not meet an established critical limit, then it should not be used as a carcass rinse until a corrective action is taken. Here are two ways to take corrective action:

1. Adjust the concentration of the lactic acid solution to reach the proper acidity (that is, add more water or acid).

2. Prepare a fresh batch of 2% lactic acid.

Carcasses should be re-rinsed with lactic acid if they are rinsed with a solution that does not meet the critical limit.

Spray Equipment Selection

There are several types of spray tanks that are suitable for this intervention. The price often varies by the available features and the materials used. This section describes the equipment used at The Pennsylvania State University for research purposes. However, there are numerous suppliers that can provide comparable spray tanks and fittings.

Heavy-duty, stainless steel tank

Laboratory studies were performed using a heavy duty, stainless steel spray tank. The tank was fitted with a 100 psi pressure gauge, 100 psi pressure relief valve, a spray wand with a flat, fan-spray nozzle, and a quick connect plug for rapid pressurization with an air compressor.

Figure 5. Heavy-duty stainless steel tank

Parts list and instructions for assembly of heavy-duty stainless steel tank

Quantity	Part description
4*	Hose adapter, type 316 SS†, barbed X male for ¼" hose I.D., ¼" pipe (53505 K64)
4*	Worm-drive hose and tube clamp, type 316 SS 7/32" to 5/8" clamp I.D. range, 5/16" band width (5011 T141)
2*	Hex nipple, precision threaded type 316 SS pipe fitting ¼" X ¼" pipe size, 1-13/32" length, 7500 psi (48805 K81)
1*	Pop-safety valve for air and gas, ASME 304 SS, ¼" NPT male, 100 psi (98905 K104)
1*	Pressure gauge, type 304 SS case, 2½" dial, ¼" NPT bottom connection, 0-100 psi (3852 K184)
1*	Compressed air regulator, SS ¼" pipe size, 0 to 125 psi range [4289 K23; regulator comes with 2 hex head plugs, high-pressure 316 SS threaded pipe fitting ¼" pipe size, 3000 psi (4443 K722)]
1*	Portable pressure tank, wide mouth, ASME type 316L stainless steel, 5 gallon capacity, 9" diameter X 22½" height (41665 K32)
1*	Ball valve, 316 SS, full-port, lockable lever handle, ¼" NPT female (46495 K58)
1**	WashJet® spray nozzle (¼ MEG-5020)
1**	UniJet® spray gun adapter, SS (4676-SS-1/4)
1**	UniJet® cap, SS (CP1321-SS)
1**	Spray gun extension assembly, SS (20400-1/4M-18-SS)
1**	GunJet® spray gun, low pressure, trigger jet, SS (AA36-1/4-SS)
1***	Quick connect coupling (plug and socket) AMFLO ¼" brass coupler/plug kit - ¼" NPT, (C20BKIT-RET)
1***	Roll of Teflon tape
1****	12' section of braided tubing 980 PVC 3/8" I.D. X 9/16

	O. D., 3/32” wall thickness (63012-483)
1****	6’ section of braided tubing 980 PVC 3/8” I.D. X 9/16 O. D., 3/32” wall thickness (63012-483)

*Parts were purchased from McMaster-Carr, Aurora, OH. McMaster-Carr part numbers are in parentheses.

**Parts were purchased from Spraying Systems Co., Wheaton, IL. Spraying Systems part numbers are in parentheses.

***Parts were purchased at Lowe’s Home Improvement Warehouse.

****Tubing was purchased from VWR International, West Chester, PA. The part number is in parentheses.

†SS = stainless steel

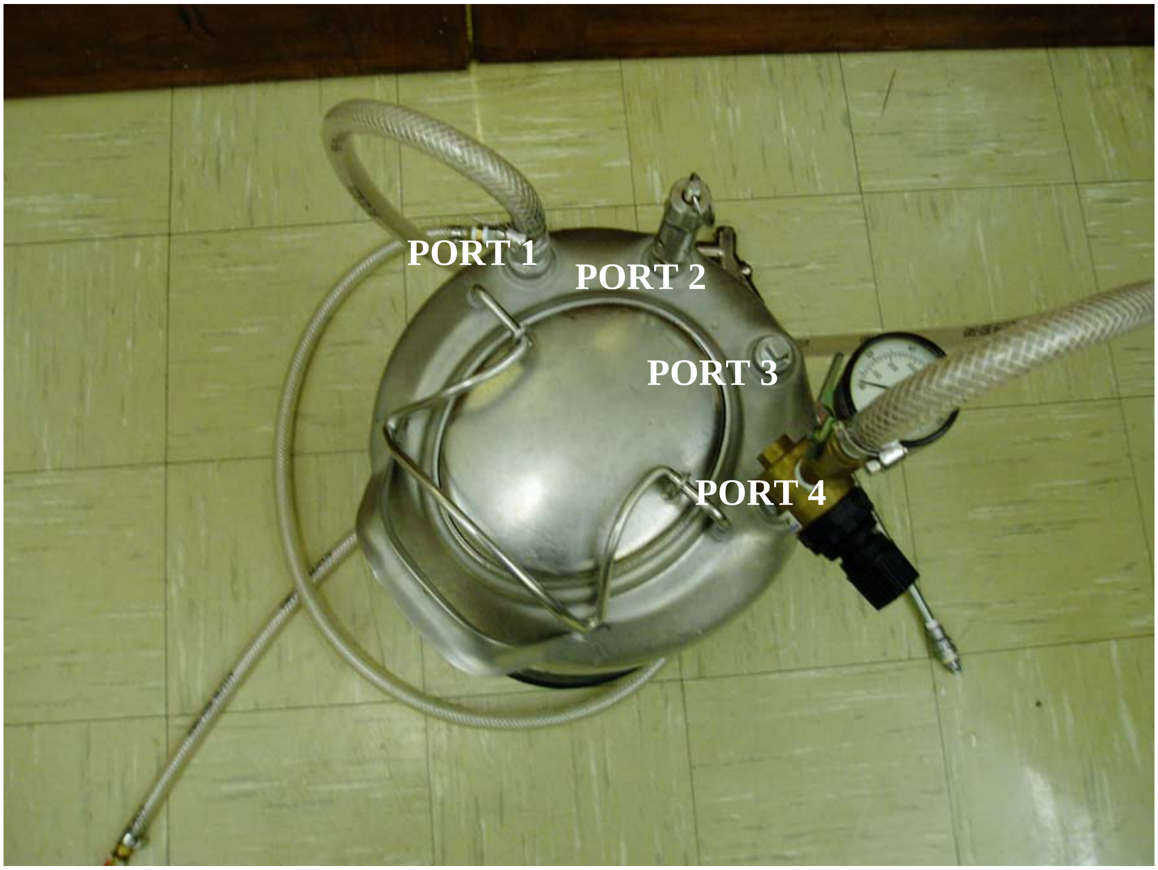


Figure 6. Close-up view of top of heavy-duty stainless steel tank

1. Insert hose barbs into the ends of the 12’ and 6’ sections of braided tubing. Secure each hose barbs inside the tubing with a worm clamp. The 12’ section will be connected to the spray wand while the 6’ section will provide an inlet for compressed air. All threaded fittings should be wrapped with Teflon tape prior to assembly.

2. Insert one of the threaded ends of the 12’ section of tubing into port 1 (Figure 6). For reference, port 1 is connected to the fluid feed inside the tank.

3. The spray wand parts should be assembled in the following order: spray nozzle, cap, spray gun adapter, extension assembly, spray gun. Make certain that the arrow on the spray gun points in the desired

direction of fluid flow. Otherwise, the spray wand will leak when the tank is pressurized.

4. Port 2 should be occupied by the pop-safety valve.

5. Assemble in the following order: hex nipple, pressure regulator, hex nipple, ball valve. Thread the available end of the first hex nipple into port 4 (see above picture).

6. Thread the 6’ section of tubing into the other end of the ball valve.

7. Attach the quick connect plug to the open barb of the 6’ section of tubing. The quick connect socket can be fitted onto the output of an air compressor.

8. Insert the pressure gauge into one of the openings of the pressure regulator. The other opening of the regulator should be occupied by a hex head plug.

9. Thread the other hex head plug into port 3.

10. Tighten all fittings and connections.

11. To test the system, first close the ball valve. Then fill the tank about halfway with water. The rubber gasket should be in place to create a tight seal at the mouth of the tank. Connect the tank to an air compressor. Open the ball valve. When the desired air pressure is achieved (40 psi is recommended), close the ball valve and disconnect the tank from the air compressor. Check the system for air or fluid leaks. Retighten the fittings as necessary so that the spray system can adequately maintain pressure.

11. After use in an antimicrobial intervention for carcass surfaces, flush the system thoroughly with clean water and allow to air dry.
Hint: During use on the kill floor, keep a plastic bag wrapped around the quick-disconnect plug to prevent debris from entering the spray tank.

Garden sprayer

This type of sprayer is relatively inexpensive and simple to operate. In general, garden sprayers operate with a gentle flow rate. Use of this sprayer to thoroughly rinse a carcass may require extra time so that an adequate amount of 2% lactic acid is dispensed. Also, many of these garden sprayers are not equipped with a pressure gauge and require manual exertion to pressurize (unless retrofitted as described below).

Figure 7. Garden sprayer

Retrofitted garden sprayer

A garden sprayer can be retrofitted so that it includes a pressure gauge, a pressure relief valve for safety, and a quick connect plug. The quick connect coupling allows the user to pressurize the tank rapidly without having to pump it manually. **A retrofitted spray tank should be pressurized and operated responsibly to ensure employee safety.**

Figure 8. Retrofitted garden sprayer

Parts list and instructions for assembly of retrofitted garden sprayer

Quantity	Part description
2	3/8" X ¼" I.D. hose barb to MIP adapter (Watts® A-293)
2	¼" Female pipe tee (Watts® A-730)
2	Hex nipple ¼" (Watts® A-729)
2	Gold Seal worm gear clamps, MM 4 SS range 1/4" - 5/8", "400" stainless screw, all stainless steel band and housing, Murray Corporation, Hunt Valley, MD
1	¼" NPT 100 PSI pressure gauge Model No. RG-2 (Part no. 05003A500, Water Ace Pump Co., Ashland, OH)
1	¼" Ball valve with threaded ends, brass, full port for maximum flow, 600 psi WOG, (M100, American Valve, Greensboro, NC)
1	Quick connect coupling, plug and socket, AMFLO ¼" brass coupler/plug kit - ¼" NPT, (C20BKIT-RET)
1	Roll of Teflon tape
1	2-gallon stainless steel Bugwiser® sprayer

All of these parts were purchased at Lowe's Home Improvement Warehouse. Part/model numbers are in parentheses.

Figure 9. Close-up view of retrofitted garden sprayer

1. Start with a fully assembled garden sprayer. A 2-gallon stainless steel Bugwiser® sprayer (H. D. Hudson Manufacturing Company, Chicago, IL) was retrofitted as described below and used in laboratory studies. A retrofitted Bugwiser® sprayer is pictured above.

2. Cut the black hose approximately 2 inches above the connection to the spray tank. Insert a 3/8" X ¼" I.D. hose barb into the exposed end of the black hose sections. Place a worm gear clamp over each hose barb connection and tighten. Teflon tape should be wrapped around the tshreaded fitting(s) of each part as necessary.

3. Connect the threaded ends of both hose sections to a ¼” female pipe tee. This first tee should be perpendicular to the hose that connects to the spray tank.

4. Insert a ¼” hex nipple into the remaining opening of the pipe tee.

5. Connect the other ¼” female pipe tee to this hex nipple.

6. Screw in the pressure gauge so that is perpendicular to the second pipe tee.

7. Place the other ¼” hex nipple into the remaining opening of the second pipe tee.

8. Thread the ball valve onto the second hex nipple.

9. Fit the quick connect plug into the opposite end of the ball valve. Tighten all fittings.

10. Fit the air compressor with the corresponding quick connect socket.

11. Drill a small hole through the black plastic collar of the spray tank. Wrap a piece of wire (approximately 24” long) securely around the fittings. Feed it through the drilled hole and secure it to the collar to stabilize the fittings. This wire support prevents the fittings from wobbling during pressurization and spraying.

12. Open the ball valve. Fill the spray tank with water and pressurize the tank with the air compressor by connecting the quick connect plug and socket. **Do not exceed 40 psi if using the 2-gallon stainless steel Bugwiser® sprayer. An overpressurized spray tank could explode and cause bodily injury.** Close the ball valve before disconnecting the spray tank from the air compressor. Check the system for leaks prior to use in an antimicrobial intervention for carcass surfaces.

13. To prolong the useful life of the retrofitted spray tank, it should be flushed with water several times after use and allowed to air dry completely.

Battery-operated sprayers

Some systems employ a rechargeable battery to operate a pump, which can deliver fluid at a constant rate and pressure. These sprayers can be found in the form of a backpack or a tank on wheels. The backpack sprayer (SRS-540 ProPack™) that was used in laboratory studies was manufactured by SHURflo, LLC, Cypress, CA.

Figure 10. Backpack sprayer

Figure 11. Spray tank on wheels

Summary

Here is a step-by-step review of this antimicrobial intervention for carcasses processed in very small establishments.

Step 1.

Thoroughly wash the carcass with warm water.
Wash beef carcasses for at least 2 minutes.
Wash other red meat carcasses for at least 1 minute.

Step 2.

Allow the carcass to drip for 5 minutes.
This action improves the effectiveness of the antimicrobial rinse.

Step 3.

Thoroughly rinse the carcass with an antimicrobial solution such as, 2% lactic acid.
Rinse beef carcasses for at least 1 minute.
Rinse other red meat carcasses for at least 30 seconds.

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