

Bacteriological Safety of Swine Carcasses Treated with Reconditioned Water

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ABSTRACT

Swine carcass microflora were evaluated for selected foodborne pathogens after exposure to reconditioned water during scalding, dehairing, and polishing operations. Reused water had been reconditioned and chlorinated. Rodac plates applied to hams were used to assess carcass microflora. Water samples were enumerated using membrane filtration or spiral plating. Sampling was at mid-week throughout the year. Total aerobic plate counts on hams were unaffected by treating with potable or reconditioned waters. No differences were observed for staphylococci, enterics, fecal streptococci, *Listeria monocytogenes*, coliforms, and *Aeromonas* levels. A preevisceration potable water carcass wash reduced the bacterial load, regardless of initial treatment. Bacterial counts on carcasses paralleled those in water. Reuse is an alternative to potable water for initial slaughter operations without diminishing bacteriological safety.

Key Words: pork, reconditioned water, bacteriology, aerobic plate counts

INTRODUCTION

WATER CONSERVATION is an important issue in pork processing, where water is consumed in large volumes for unit operations. A need to reduce water consumption has resulted from wastewater discharge restrictions as well as from water shortages (Steffen, 1981). Inplant water conservation would be effective to reduce operating costs as well, since water reuse programs could potentially reduce total water consumption and effluent BOD. Such programs have been generally limited to poultry processing and inedible by-product operations. Research has indicated potential value for reconditioned/recycled water use on edible poultry products (Carawan et al., 1974; Lillard, 1978a, 1978b). For water reuse by the pork industry, its efficacy and safety must be demonstrated. Our objective was to determine if the use of reconditioned water would alter the microbiological flora of swine carcasses in a pork processing plant.

MATERIAL & METHODS

Swine slaughter

All swine microflora data were collected at Hatfield Quality Meats, Hatfield, PA. Pigs were of mixed breeds and weighed 109 kg (on average). A summary of the slaughter unit operations is shown in Fig. 1. Stunning was by electrocution, exsanguination was performed by severing the carotid arteries, and scalding was by immersion in 60°C potable or reuse water for 6 min. No additives were included in the scalding trough, which had an overflow rate of 22.7 L/min. Dehairing was done with 3 dehairing and 2 polishing machines (Nijhus, The Netherlands); potable or reuse water for these unit operations was applied by spraying. Carcass and water sampling was done on Wednesdays at about 10 a.m., 4 hr after slaughter commencement; data were obtained during all seasons between January, 1991 and May, 1992.

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Water reconditioning and reuse

Prior to treatment, the pH of the waste water was adjusted to 5.7–6.0. Reuse water was treated (Fig. 2) by flocculation, dissolved air flotation, anaerobic denitrification, aerobic nitrification (dissolved oxygen [DO] is 1–4 mg/L), clarification, sand filtration (following this step, the DO was 5+ mg/L), and chlorination (following chlorination, the oxidation-reduction potential was 600–800 mV). For all experiments, potable water was the control. Switchover between the two systems occurred ≥ 48 hr prior to sampling.

Bacteriological media

The following plating media were used: Tryptone glucose extract (TGE; Difco, Detroit, MI), Baird-Parker (BP; Difco), Hektoen Enteric (HEK; Difco), KF-Streptococcus (KF; Difco), MacConkey (MAC;

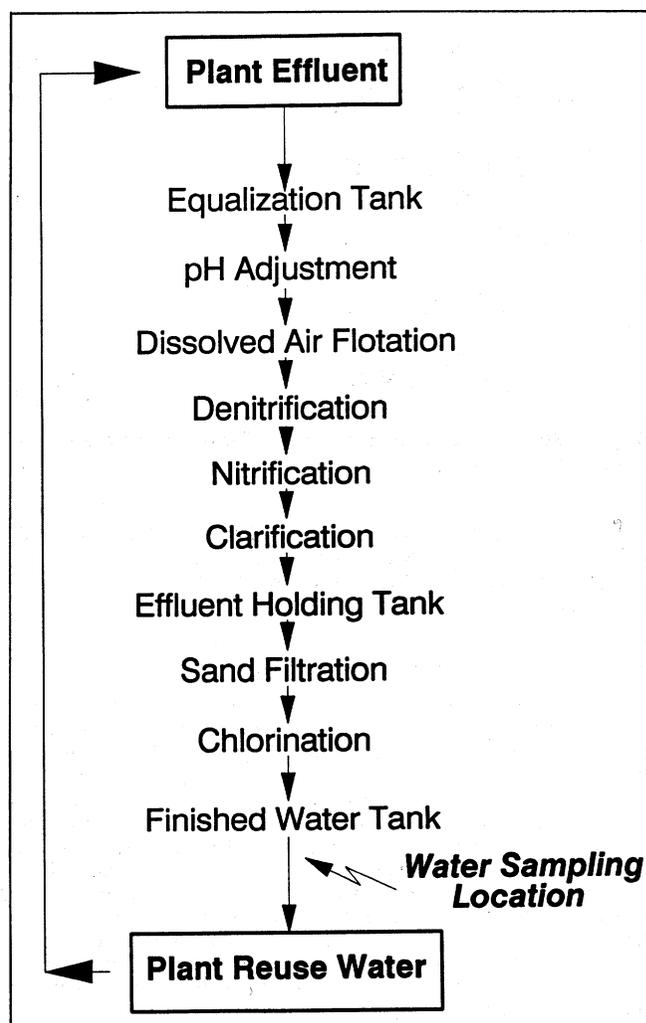


Fig. 1—Steps for reconditioning water for reuse (details in Materials & Methods).

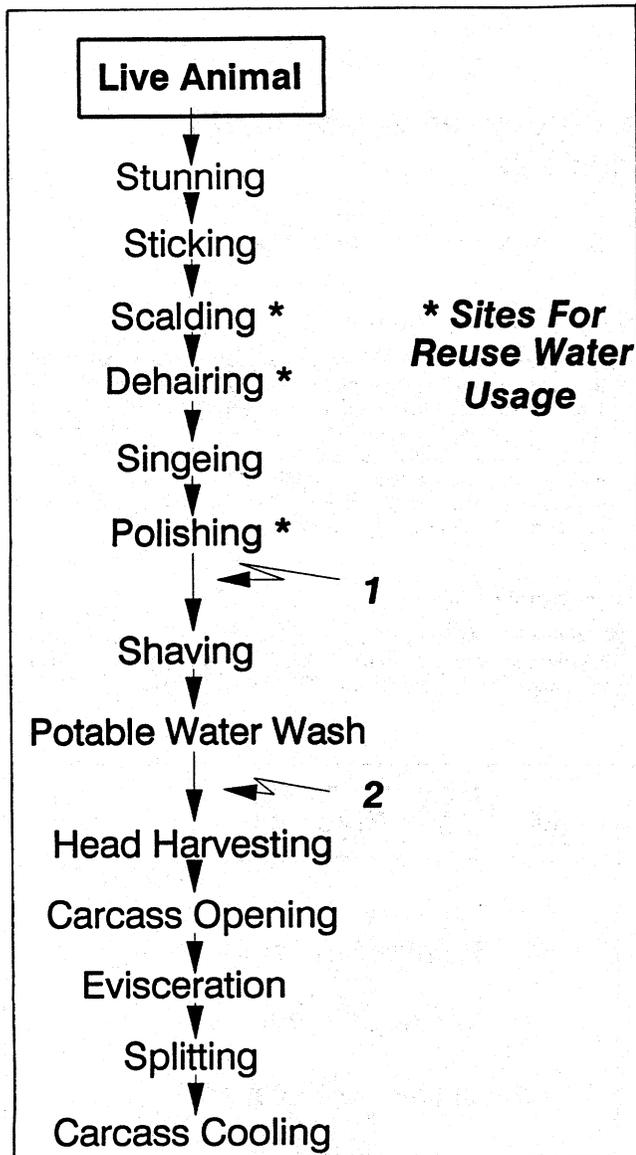


Fig. 2—Steps in swine slaughter operation with reuse water and carcass sampling locations. (1) and (2)—Carcass sampling locations.

Ditco), Modified Vogel-Johnson (MMVJ; Smith and Buchanan, 1990) and Starch Ampicillin (SAA; Palumbo et al., 1985) agars. Media, presumptive organisms they detect, incubation conditions, and typical colony characteristics are described in Table 1.

Carcass sampling and bacteriological analysis

The first experimental series was performed to determine the most suitable sampling sites on carcasses. Samples were obtained after dehairing and polishing (Fig. 1, location 1) from the ham, belly, and shoulder portions of hanging carcasses to determine if anatomical location affected bacterial population density. Ten random carcasses were sampled, each at the 3 sites. For all studies involving carcass sampling, Rodac (Becton Dickinson, Lincoln Park, NJ) dishes (65 mm diameter) were used which contained various media. Rodac dishes were held in contact with carcasses for 2 sec and transported at ambient temperature to the laboratory for incubation (see Table 1) and subsequent enumeration. The ready incorporation into processing operations was another reason for using Rodac dishes instead of swabbing or excision methods which are more time consuming or would damage the carcass. Preliminary experiments indicated that 2 sec was the optimal contact period. For each trial 30 Rodac plates were used for each of seven media. Counting was manual.

The second experimental series compared the effect of using potable or reuse water during initial stages of slaughter on the carcass surface

microflora. All sampling was after polishing, using either of the two hams as the sampling site (Fig. 2, location 1). Ten trials were performed consisting of five each, for potable and reuse water treatments. Thirty Rodac plates were employed for each of the seven media. Pigs from multiple lots (210 total) were used for each trial.

In a third experimental series the effect of the final potable wash on carcass bacterial microflora was assessed. Samples were obtained after dehairing/polishing (Fig. 2, location 1) with reuse or potable water, and after the final potable carcass wash (Fig. 2, location 2), prior to evisceration. Six trials were performed consisting of three each of potable and reuse prewash treatments. Fifteen Rodac plates were employed for the seven media. The 210 carcasses used for each treatment trial (105 for prewash sampling and 105 for postwash sampling) were randomly chosen.

Water sampling and bacteriological analysis

Quality of reconditioned water was evaluated immediately after treatment, prior to its return to the plant for reuse. Potable samples were obtained from water lines within the plant, immediately before use in slaughter operations. Lines were purged for at least 5 min prior to collection of samples into sterile 4L plastic containers. Water samples were obtained within 1 hr after carcass sampling. Samples were obtained generally in duplicate for the ten trials, consisting of five each for potable and reuse water. Each container was prepared with 0.1 mL of a 10% solution of sodium thiosulfate per 100 mL of water sample, to neutralize residual chlorine (Greenberg et al., 1981). Water samples were cooled immediately on ice, and transported to the laboratory for processing and analysis within 2 hr after collection. Samples were plated onto media (Table 1). The analyses were performed by either surface plating using a Spiral Plater (Model D, Spiral Systems, Cincinnati, OH) or by filtering 50 mL of water through a 0.45 µm nitrocellulose filter (#130-4045, Nalgene Co, Rochester, NY), then aseptically transferring the filter to the surface of standard Petri dishes (100 × 15 mm) which contained various media. Incubation conditions of media were identical to those used for carcass samples (Table 1). Enumeration was performed by either electronic counting using a Laser Colony Counting System Model 550A (Spiral Systems), or manual counting.

Statistical analysis

Viable cell counts from potable or reconditioned water samples and carcasses (Fig. 1, sampling site 1) were analyzed using a general linear models procedure (SAS[™] Institute Inc, Cary, NC). Analyses comparing water sources were performed using nested models, with the sampling date nested within the water source as the error term for water source effects. Studies to evaluate the effects of a pre-evisceration potable carcass wash (Fig. 2, sampling site 1 vs site 2; Table 4) were analyzed using a randomized complete block design. Blocks in this case consisted of sampling date, thus date × location (i.e., block × treatment) was the error term.

RESULTS

NO DIFFERENCES OCCURRED ($P > 0.05$) in bacterial flora on ham surfaces washed with the two water sources (Table 2). Mean population densities for total aerobic plate counts were < 50 CFU/cm² for potable and reconditioned water and coliforms were < 10 . No differences occurred ($P > 0.05$) in other measures of microflora quality or safety. Coagulase positive staphylococci on carcasses from potable and reconditioned treatments were very low as were total enteric bacterial loads and fecal streptococcal and *Aeromonas* levels. No *L. monocytogenes* were detected on any of the carcasses.

Similarly, no differences occurred ($P > 0.05$) between bacteriological quality of the potable and reconditioned waters (Table 3). Total aerobic plate counts were below 200 for potable water and for reconditioned water and total coliforms < 15 . Coagulase positive staphylococcal levels were < 6 , total enteric bacterial < 2 , fecal streptococci < 0.1 , and *Aeromonas* levels < 0.2 in all cases from either water. No *L. monocytogenes* was observed in any water samples.

Improvements in the bacteriological quality of ham surfaces occurred as the result of a final potable water carcass wash

Table 1—Bacteriological media, incubation conditions, and colony identifications for water and carcass samples

Presumptive organism	Agar medium	Incubation conditions	Typical colonies ^a
Total Aerobic Plate Counts (TAPC)	Tryptone Glucose Extract (TGE)	24 hr, 28°C	Nonselective
Coag(+) staphylococci	Baird-Parker (BP)	48 hr, 37°C	Black, shiny, convex, clear zone
Total enterics	Hektoen Enteric (HEK)	24 hr, 37°C	<i>Shigella</i> : green, moist, raised <i>Salmonella</i> : blue green or black <i>Coliforms</i> : salmon pink-orange
Fecal streptococci	KF-Streptococcus (KF)	48 hr, 37°C	Red
Coliforms	MacConkey (MAC)	24 hr, 37°C	Pink, red, or colorless
<i>Listeria monocytogenes</i>	Modified Vogel-Johnson (MMVJ) ^b	48 hr, 37°C	Black ^b
<i>Aeromonas</i>	Starch Ampicillin (SAA) ^c	24 hr, 28°C	Honey-colored (3-5mm), amylase positive ^c

^a Difco (1985), except where noted.

^b Smith and Buchanan (1990).

^c Palumbo et al., (1985).

Table 2—Bacterial counts of ham surfaces washed with potable vs. reconditioned water

Presumptive organism	Potable			Reconditioned		
	Mean ^a	SE ^a	n ^b	Mean ^a	SE ^a	n ^b
TAPC ^c	44.1	12.3	147	49.4	14.0	146
Coag (+) staphylococci	0.4	0.1	151	2.5	1.6	156
Total enterics	1.0	0.5	152	2.1	0.8	143
Fecal streptococci	<0.1	<0.1	151	0.5	0.4	154
Coliforms	3.3	1.1	151	8.7	5.1	150
<i>Listeria monocytogenes</i>	N.D. ^d	N.D.	149	N.D.	N.D.	157
<i>Aeromonas</i>	<0.1	<0.1	148	0.5	0.4	145

^a CFU/cm².

^b Total observations in five replicate experiments.

^c TAPC = Total Aerobic Plate Count.

^d N.D. = None Detected.

Table 3—Bacterial content of potable vs reconditioned water

Presumptive Organism	Potable			Reconditioned		
	Mean ^a	SE ^a	n ^b	Mean ^a	SE ^a	n ^b
TAPC ^c	187.1	68.5	8	100.3	31.5	10
Coag (+) staphylococci	<0.1	<0.1	8	6.0	1.9	10
Total enterics	1.7	0.9	8	<0.1	<0.1	10
Fecal streptococci	<0.1	<0.1	8	<0.1	<0.1	10
Coliforms	8.2	4.8	8	12.0	4.8	10
<i>Listeria monocytogenes</i>	N.D. ^d	N.D.	8	N.D.	N.D.	10
<i>Aeromonas</i>	<0.1	<0.1	8	0.2	0.1	10

^a CFU/ml.

^b Total observation in 5 replicate experiments.

^c TAPC = Total Aerobic Plate Count.

^d N.D. = None Detected.

(Table 4). Reductions ($P < 0.05$) occurred in total aerobic plate count (67%), total enteric bacteria (91%), and coliforms (91%) when the carcass was washed with potable water after scalding and dehairing. When reconditioned water was used for initial slaughter operations, the potable carcass wash reduced bacterial levels by 65%, for total aerobic plate count, 79% for total enteric bacteria, and by 83% for coliforms. No differences ($P > 0.05$) occurred in microflora after carcasses were treated with a final potable wash.

The analysis of variance indicated a significant effect on total aerobic plate count ($P < 0.05$) due to sampling date. Major sources of variation appeared to be ambient temperature and operational changes in water reconditioning.

DISCUSSION

Considering maintaining carcass flow on the processing line, use of contact plates (Rodac dishes) on the ham surface would provide an adequate procedure to assess the influence of water source on microbiological quality of hog carcasses. To detect and quantify the different pathogens and indicator groups surveyed, various selective media were useful (Table 1). Patho-

Table 4—Bacterial counts after a final potable wash on ham surfaces initially processed with potable or reconditioned water

Organism	Water source	Location				
		Prewash ¹		Postwash ²		F-Value ^a
		Mean ^b	SE ^b	Mean ^b	SE ^b	
TAPC ^c	Potable	75.9	27.5	24.8	11.9	6.85*
	Reuse	44.7	9.0	15.6	6.5	
	F-Value	1.58				
Coag(+)Staphylococci ^d	Potable	0.2	0.2	0.03	0.03	1.79
	Reuse	0.9	0.5	0.2	0.1	
	F-Value	1.24				
Enterics	Potable	3.5	2.1	0.3	0.1	9.49*
	Reuse	3.9	1.0	0.8	0.3	
	F-Value	0.34				
Coliforms	Potable	9.8	5.4	0.9	0.3	7.79*
	Reuse	18.3	6.7	3.1	1.5	
	F-Value	1.51				
<i>Aeromonas</i>	Potable	1.1	0.7	0.03	0.02	3.12
	Reuse	1.0	0.6	0.3	0.2	
	F-Value	0.0				

^a Values followed by * are significantly different ($P < 0.05$).

^b CFU/cm²; SE = $s^2(p)/45 + s^2(d)/3$, where 45 = reps (15) × sampling days (3); $s^2(p)$ = within day variability; $s^2(d)$ = between day variability.

^c Total Aerobic Plate Count.

^d Coagulase positive staphylococci.

* 1/2 locations 1 and 2 in Fig. 1.

gens as well as most other bacteria can be injured by various treatments such as heating (singeing and scalding), chlorine, etc. (Ray, 1989) and selective media typically do not provide quantitative recovery of injured bacteria. Most procedures we used would preclude detection of injured cells equally, regardless of treatment with reconditioned or potable water. Two of the selective media, (BP and MMVJ), were formulated to enhance recovery of injured cells of *Staphylococcus aureus* and *L. monocytogenes*, respectively (Baird-Parker, 1962; Smith and Buchanan, 1990).

Use of recycled water has been reported in the poultry industry for inedible products, and was shown experimentally to be efficacious and safe for certain edible products. For example, poultry chiller water was recycled after filtration through diatomaceous earth and chlorination (Lillard, 1978b). The safety and quality of the water and product were maintained when poultry necks were flumed with reconditioned water (Lillard, 1978a). Carawan et al. (1974) showed that flushing gizzards with water from the chiller and final washer had no detrimental effect on bacteriological quality of the gizzards.

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