Reducing Bacteria in Household Sponges

Judy Y. Ikawa, M.S.,
Jonathan S. Rossen, M.S.

Abstract

A used sponge contains bacteria that multiply rapidly under favorable conditions. Usually, nutrients and moisture in the sponge are sufficient to support growth of these micro-organisms. Successive use of the same dirty sponge can transfer bacteria from one surface to another during the "cleaning" process. To minimize the potential spread of bacteria, sponges should be decontaminated regularly. In this study, several physical and chemical decontamination methods were evaluated. Heating a contaminated sponge for one minute in a microwave oven or boiling a sponge in water for five minutes resulted in a more than 99.9 percent reduction in the number of bacteria. Soaking contaminated sponges for five minutes in a solution of bleach or a cleaner that contains a quaternary ammonium compound also resulted in a more than 99.9 percent reduction of bacteria. Other products such as hydrogen peroxide, isopropyl alcohol, ammonia, and vinegar were effective in reducing the bacterial load in laboratory-inoculated sponges but not in consumer-used sponges, which contained a higher concentration of bacteria.

Introduction

Each year in the United States, an estimated 5.5 million to 6.5 million cases of food poisoning occur (1). In Europe, studies have shown that many foodborne-disease outbreaks occur in the household environment as a result of improper food preparation (2). Implicated in many instances is cross-contamination or direct contamination of food contact surfaces resulting from improper food handling, preparation, or storage (2).

Vehicles for spreading food pathogens include wet dishcloths and sponges (3–6). Many investigators have recognized the potential for dishcloths or sponges to spread micro-organisms and have noted that bacteria persist in these media (7,8). Bacteriological surveys conducted for kitchen dishcloths or sponges have revealed the presence of many enteric pathogens, such as *Escherichia coli, Klebsiella pneumoniae*, and *Enterobacter cloacae* (3,4,6). These enteric pathogens survive and multiply in wet environments like dishcloths and sponges. Other types of pathogens, such as *Staphylococcus aureus* and *Salmonella* sp., as well as opportunistic pathogens such as *Pseudomonas* sp., also have been isolated. Thus, dishcloths or sponges containing high concentrations of pathogens may be reservoirs and disseminators of bacterial contamination in the kitchen (3).

Adequate cleaning and decontamination of food contact surfaces, dishcloths, and sponges may minimize the spread of micro-organisms in the kitchen. Sponges are commonly used to clean food contact surfaces such as cutting boards, pots and pans, dishes, countertops, sinks, refrigerator and faucet handles, and stovetops. Simple, effective methods for reducing micro-organisms in sponges have not been evaluated, except for disinfection of sponges and dishcloths in the microwave oven (9). This study evaluated different types of chemical and physical treatments for decontaminating scrubber sponges (greater than 99.9 percent reduction of bacteria). (Scrubber sponges incorporate scrim material that cleans by abrasion.) The treatments were initially applied to laboratory-inoculated sponges and then verified to be effective with testing on consumer-used sponges.

Methods

Experimental Test Organisms for Laboratory-Inoculated Sponges

The following species of bacteria were used in this study: *Escherichia coli* ATCC 11229, *Salmonella choleraesuis* ATCC 10708, *Pseudomonas aeruginosa* ATCC 15442, *Staphylococcus aureus* ATCC 6538, and *Shewanella putrefaciens* ATCC 8071.

The bacteria were grown in trypticase soy broth incubated at 35° C. After at least three consecutive daily transfers, the final culture was grown in trypticase soy broth at 35° C for 24 hours. The organisms were harvested by centrifugation, and concentration was adjusted according to optical density with a spectrophotometer. Single species of bacteria at equivalent concentrations were combined to prepare a composite inoculum. The composite concentration was verified by enumeration on letheen agar incubated at 35° C for two days.

Laboratory Sponge Preparation

Household scrubber sponges were thoroughly rinsed by hand to wash out the magnesium chloride (humectant) and quaternary ammonium compound (mildew-static compound). These compounds were washed out to simulate a "used" condition. Sponges were dried at room temperature for several days and stored in bags.

The pour plate technique with letheen agar was used for determining bacterial concentrations. Prior to inoculation, no counts (fewer than 10 CFU per sponge) were detected in the scrubber sponges to be inoculated. For inoculation, each sponge was wetted with 54 milliliters (mL) of sterile distilled water and contaminated with 1.0×10^5 to 2.0×10^6 total bacteria (4 mL). To mix the bacteria, researchers squeezed each sponge several times and allowed the liquid to resaturate into the sponge, held in a storage bag. The sponges were stored at 25° C for two days to allow the bacteria to acclimatize to the sponge environment. After two days, counts from contaminated sponges were 1.0×10^5 to 1.0×10^6 CFU per sponge (pretreatment counts). For each treatment, the number of sponges tested varied from two to 12. After treatment, each sponge was rinsed with water and the effluent was diluted to neutralize the treatment. Plating with letheen agar followed immediately.

Consumer-Used Sponges

Different brands of household scrubber sponges were collected from consumers who had used the sponges as they normally would in the kitchen area (one- to two-week usage). Pretreatment and posttreatment plating was conducted with letheen agar on the consumer-used sponges. The number of sponges tested varied from two to 10, depending on availability. The chemical and physical treatments are described below.

Chemical Treatments

Six chemical treatments were tested:

1. Regular Clorox® Bleach diluted with tap water at a ratio of 1:21.3 (3/4 cup per gallon);
2. Sav-On Solution of three percent hydrogen peroxide, undiluted;
3. Sav-On 70 Percent Isopropyl Rubbing Alcohol, undiluted;
4. Formula 409® (All Purpose Cleaner, Now Kills Bacteria!) both undiluted and diluted with tap water at a ratio of 1:2;
5. Parson's® Lemon Fresh Ammonia, diluted with tap water at a ratio of 1:32; and
6. Lady Lee® White Distilled Vinegar, undiluted.

The average wet weight of a sponge was 70 grams (g) ± 5 g. Before the sponge effluent was diluted for counts, the total weight of the sponge was adjusted with water to 70 g. The purpose of this step was to standardize the starting dilution. Sponges were soaked in 100 mL volume of undiluted or diluted test solution. Activity of the chemical treatment was then neutralized by thorough rinsing with tap water after five minutes of exposure. A 1 mL aliquot of rinse water squeezed from the sponge was transferred into 9 mL of letheen broth supplemented with 0.1 percent sodium thiosulfate. Further 10-fold dilutions were prepared with letheen broth supplemented with 0.1 percent sodium thiosulfate as diluent. The pour plate technique was used for plating dilutions from 10^{-1} to 10^{-4} for laboratory-inoculated sponges and dilutions from 10^{-2} to 10^{-7} for consumer-used sponges.

TABLE 1

Reduction of Bacteria in Laboratory-Inoculated Sponges After Physical Treatment*

Treatment	Sponges Treated	Average Pretreatment Count	Average Posttreatment Count	Range of Posttreatment Count	Bacterial Reduction (%)**
Washing machine —no detergent or bleach	10	1.7×10^5	12	<10–30	99.993
Dishwasher —no detergent	10	1.4×10^5	62	<10–140	99.96
Washing machine —no detergent or bleach	5	4.0×10^5	<10	<10	99.998
Microwave oven	5	2.5×10^5	<10	<10	99.9996

*Unit of measure is CFU per sponge.
**Based on average count, determined by: $\frac{\text{Average Pretreatment Count} - \text{Average Posttreatment Count}}{\text{Average Pretreatment Count}} \times 100$

Neutralization Verification

An uninoculated sponge was exposed to the same chemical treatment conditions as the inoculated sponges. Triplicate 1 mL aliquots of liquid squeezed from the treated, uninoculated sponge were combined with 9 mL of letheen broth supplemented with 0.1 percent sodium thiosulfate. Approximately 200 total composite bacteria were inoculated into triplicate broth tubes containing treatment liquid. The broth cultures were incubated at 35° C for two days. Growth in all culture tubes verified neutralization.

Physical-and-Chemical Combination Treatments

Two treatment methods were tested.

1. A Whirlpool washer and Whirlpool dryer were tested as follows: Each load consisted of a sponge, 61 pounds of poly-cotton ballast, and a soiled pillow case. All loads

were agitated for 12 minutes at 34° C and dried for 60 minutes. On certain trials (for consumer-used sponges only), Tide® (1/4 cup) and Regular Clorox Bleach (1.5 cups) were added to the wash load.

2. A Kenmore dishwasher was tested as follows: One load consisted of one to three sponges on the top rack, soiled dishes, utensils, and glass cups washed with or without detergent for consumer-used sponges and without detergent for laboratory-inoculated sponges. Tests were conducted both with and without the hot dry cycle.

Physical Treatments

Two physical treatments were tested:

1. boiling—sponges were boiled in tap water for five minutes—and
2. Sharp microwave oven—a wet sponge in a storage bag was heated in the microwave oven for one minute on the highest power. (Sponges need to be wet before being heated in the microwave. Also, care was taken to avoid heating the sponges to dryness to preclude the possibility of a sponge catching fire.)

The treated sponges were analyzed for bacteria counts immediately after they had cooled to room temperature. To normalize the starting dilution, researchers adjusted the total wet weight of each sponge with water to about 70 g ± 5 g. Liquid (1 mL) squeezed from the treated sponge was combined with 9 mL letheen broth for diluting. Plating was conducted using letheen agar.

Results

Table 1 and Table 2 summarize results for laboratory-inoculated sponges. Table 3 and Table 4 summarize results for consumer-used sponges. For the purposes of this study, an effective treatment is defined as 99.9 or greater reduction in the number of bacteria. This definition is similar to the U.S. Environmental Protection Agency (U.S. EPA) requirement for a non-food-contact sanitizer (10). For the purpose of this paper, a scrubber sponge used for cleaning is considered to be a non-food-contact surface since the sponge does not come in direct contact with food.

TABLE 2

Reduction of Bacteria in Laboratory-Inoculated Sponges after Chemical Treatment*

Treatment	Sponges Treated	Average Pretreatment Count	Average Posttreatment Count	Range of Posttreatment Count	Bacterial Reduction (%)**
Bleach—1:21.3 dilution	5	1.9×10^7	<10	<10	99.9999
Hydrogen peroxide	2	4.0×10^5	<10	<10	99.998
Isopropyl alcohol	2	4.0×10^5	<10	<10	99.998
Formula 409					
1:2 dilution	10	5.5×10^6	132	<10–620	99.998
undiluted	12	7.3×10^6	<10	<10	99.9998
Ammonia	2	4.0×10^5	<10	<10	99.998
Vinegar	2	4.0×10^5	<10	<10	99.998

*Unit of measure is CFU per sponge.

**Based on average count, determined by: $\frac{\text{Average Pretreatment Count} - \text{Average Posttreatment Count}}{\text{Average Pretreatment Count}} \times 100$

Discussion

For laboratory-inoculated sponges, all chemical and physical treatments were effective in producing a greater than 99.9 percent reduction of bacteria (Table 1 and Table 2). For consumer-used sponges, physical treatments (boiling, heating in the microwave oven) and the combination of physical and chemical treatments (dishwashing with detergent or laundering with detergent and bleach) were effective in reducing the bacterial load more than 99.9 percent (Table 3). Laundering without detergent and bleach reduced the total number of bacteria by 90 percent in consumer-used sponges. Dishwashing without detergent resulted in adequate reduction of bacteria (99.9 percent) in consumer-used sponges.

Bleach and Formula 409 were the only chemical treatments that were effective on consumer-used sponges (Table 4). The other chemical treatments (vinegar, ammonia, alcohol, hydrogen peroxide) resulted in less bacteria reduction (about 56 percent to 98 percent) (Table 4).

Heating sponges in a microwave oven has been previously investigated as a means of reducing bacteria counts (9). Park and Cliver inoculated the sponges with single bacterial strains, with an initial concentration of 1.0×10^9 CFU per sponge. Heating cellulose sponges for 30 seconds gave a reduction of more than 99.9 percent (eight logs) of *E. coli* O157:H7, or *Staphylococcus aureus*. Our study also demonstrated a greater than 99.9 percent reduction in one minute for composite test organisms initially inoculated at about 2.0×10^6 (five logs reduction or 99.999 percent reduction) (Table 1). Heating consumer-used sponges in a microwave oven for one minute verified the effectiveness of this procedure in reducing the bacteria load by five logs (Table 3). Boiling cellulose sponges for five minutes gave similar results. For both laboratory-inoculated and consumer-used sponges, there was about a five-log reduction (Table 1 and Table 3).

Laundering without bleach and detergent and dishwashing without detergent reduced the bacterial load by more than 99.9 percent in laboratory-inoculated sponges (Table 1). For consumer-used sponges, the dishwashing treatment without detergent (but with the heat cycle) and the dishwashing treatment with detergent (but without the heat cycle) were similarly effective (99.9 percent), even though the dishwasher contained soiled dishes, utensils, and glassware (Table 3). The use of both detergent and heat cycle improved bacteria reduction 1,000-fold (99.9999 percent reduction). Laundering consumer sponges without detergent and bleach did not significantly reduce bacteria (Table 3). Similarly, Scott and Bloomfield have found that washing and rinsing dishcloths gives limited reduction in microbial contamination—63.8 percent reduction in CFU per square centimeter (CFU/cm^2) (11). In that study, detergent washing, rinsing, and drying at 80° C for two hours resulted in effective decontamination—99.99 percent reduction in CFU/cm^2. In the present study, the one-hour dry cycle at approximately 77°

C was ineffective, perhaps because of the shorter drying time or because the presence of ballast material in the drying load resulted in insufficient heating of the sponge. For laundering to be an effective method, detergent with bleach or some other disinfectant should be added to the wash load.

Several investigators have shown the effectiveness of adding disinfectants and detergent to a wash load. The use of 160 parts per million (ppm) or 320 ppm available chlorine with an anionic detergent in wash water resulted in a 99.8 percent reduction of bacteria in the wash water and a 99.4 percent reduction in CFU/cm^2 for a cotton swatch (12). Diapers laundered at 54° C with 200 ppm available chlorine inactivated poliovirus in two minutes (13). Quaternary ammonium compound at 150 ppm resulted in 97 percent microbial kill in wash water (14). In our study, the effectiveness of the laundering treatment improved significantly with the combination of detergent and bleach to greater than four logs of bacterial reduction (more than 99.99 percent) (Table 3).

Just as disinfectants can be effective with laundering, soaking the sponge in a disinfectant solution was highly effective in reducing the total number of bacteria. In this study, two U.S. EPA–registered disinfectants (Clorox Bleach and Formula 409) significantly reduced the bacterial load in laboratory-inoculated sponges (99.998 percent reduction) (Table 2). Other products (hydrogen peroxide, isopropyl alcohol, ammonia, and vinegar) were also effective on laboratory-inoculated sponges (Table 2).

Consumer-used sponges treated with bleach and Formula 409 showed at least a

TABLE 3

Reduction of Bacteria in Field Sponges after Physical and/or Chemical Treatment*

Treatment	Sponges Treated	Average Pretreatment Count	Average Posttreatment Count	Range of Posttreatment Count	Bacterial Reduction (%)**
Laundering —no bleach or detergent	3	2.9×10^8	2.8×10^7	8.8×10^6–6.0×10^7	90.3
Laundering with detergent —no bleach	2	2.2×10^7	6.0×10^5	4.2×10^5–7.7×10^5	97.3
Laundering with detergent and bleach	5	3.6×10^8	6.7×10^3	190–1.4×10^4	99.998
Dishwashing with heat cycle on —no detergent	10	3.0×10^8	2.0×10^5	820–1.2×10^6	99.93
Dishwashing with detergent —heat cycle off	2	4.9×10^7	2.4×10^4	6.7×10^3–4.2×10^4	99.95
Dishwashing with detergent and heat cycle	10	5.8×10^8	669	20–1.4×10^3	99.9999
Boiling	5	1.5×10^9	19	<10–40	99.999999
Microwave oven	5	1.6×10^7	146	<10–360	99.999

*Unit of measure is CFU per sponge.
**Based on average count, determined by: $\frac{\text{Average Pretreatment Count} - \text{Average Posttreatment Count}}{\text{Average Pretreatment Count}} \times 100$

TABLE 4

Reduction of Bacteria in Field Sponges after Chemical Treatment*

Treatment	Sponges Treated	Average Pretreatment Count	Average Posttreatment Count	Range of Posttreatment Count	Bacterial Reduction (%)**
Bleach—1:2.3 dilution	5	3.7×10^8	700	40–1.3×10^3	99.9998
Hydrogen peroxide	4	7.3×10^6	3.2×10^6	4.6×10^5–5.5×10^6	56.2
Isopropyl alcohol	5	4.8×10^7	8.4×10^4	180–3.7×10^5	99.83
Formula 409					
1:2 dilution	10	3.3×10^8	7.5×10^4	<10–3.3×10^5	99.98
undiluted	10	3.5×10^7	1.2×10^4	<10–6.7×10^4	99.97
Ammonia	5	3.8×10^7	9.0×10^5	2.1×10^3–2.6×10^6	97.6
Vinegar	5	1.3×10^8	1.8×10^6	1.0×10^3–7.5×10^6	98.6

*Unit of measure is CFU per sponge.
**Based on average count, determined by: $\frac{\text{Average Pretreatment Count} - \text{Average Posttreatment Count}}{\text{Average Pretreatment Count}} \times 100$

three-log reduction (99.9 percent) in bacteria, as expected because of the known level of active ingredients in these products (Table 4). Other studies have shown that greater than 300 ppm sodium hydrochloride was needed to show antimicrobial effects against *Listeria monocytogenes* when a bacterial suspension was combined with disinfectant rinse solution from a sponge (15). Scott and Bloomfield have demonstrated that for dishcloths, 4,000 ppm available chlorine was sufficient to decrease the bacterial load by 99.9 percent in two minutes (10). For consumer-used sponges, the present study produced a similar level of reduction with 2,400 ppm of available chlorine (1:21.3 dilution) in five minutes (Table 4).

Lee showed the antimicrobial activity of commercial benzalkonium chloride against *L. monocytogenes* at levels of greater than 0.1 percent when a bacterial culture was treated with disinfectant solution squeezed from sponges (15). In a study by Roessler and Hoyt, the quaternary-based disinfectant cleaner reduced the total bacteria and total and fecal coliforms from two to three logs (a 99 percent to 99.9 percent reduction) within 30 minutes (16). In the present study, however, Formula 409 (a quaternary-based disinfectant) produced a 99.9 percent reduction within a shorter time of five minutes.

Parnes has reported that other products such as ammonia and vinegar were ineffective in killing bacteria on a sponge used to wipe a ceramic or formica surface contaminated with *S. aureus* (17). The results of this study were similar: Applied to consumer-used sponges, products such as hydrogen peroxide, vinegar, ammonia, and alcohol were ineffective (Table 4). Use of these products for sponge decontamination is not advisable, because laboratory-inoculated sponges do not adequately represent domestic conditions. This study demonstrates that to determine the efficacy of a sponge treatment on sponges used in a realistic consumer environment, consumer-used sponges must be included in the testing.

This study found that several types of chemical and physical treatments were effective in reducing bacteria in sponges. Boiling yielded greater than 99.9 percent reduction of bacteria for consumer-used sponges, as did heating in a microwave oven. Disinfectant products were consistently more effective than the other chemical treatment products. Combinations of physical and chemical treatments also significantly reduced the bacterial populations.

Testing of consumer-used sponges, which were more difficult to sanitize than laboratory-inoculated sponges, validated these treatments. Under the test conditions, the population of bacteria in sponges subjected to kitchen usage was verified to be heartier than laboratory-grown bacteria. The treatments determined to be effective in this study can be used to decrease the bacterial load in sponges and can reduce the cross-contamination associated with unsanitary kitchen practices.

Corresponding Author: *Judy Ikawa, Senior Microbiologist, Clorox Services Company, 7200 Johnson Drive, Pleasanton, California 94588-8004.*

REFERENCES

1. Roberts, T. (1988), "Salmonellosis Control: Estimated Economic Costs," *Poultry Science*, 67:937-943.
2. Sheard, J.B. (1986), "Food Poisoning in England and Wales During 1983," *Environmental Health*, 94:57.
3. Enriquez, C.E., R. Enriquez-Gordillo, C.P. Gerba, and D.I. Kennedy (1997), "Bacteriological Survey of Used Cellulose Sponges and Cotton Dishcloths from Domestic Kitchens," *Dairy, Food, and Environmental Sanitation*, 17:20-24.
4. Finch, J.E., M. Hawksworth, and J. Prince (1978), "A Bacteriological Survey of the Domestic Environment," *Journal of Applied Bacteriology*, 45:357-364.
5. Mendes, M.F., E.H. Lynch, and C.A. Stanley (1978), "Bacteriological Survey of Kitchens," *Environmental Health*, 86:227-231.
6. Scott, E., C.G. Barlow, and S.F. Bloomfield (1982), "An Investigation of Microbial Contamination in the Home," *Journal of Hygiene, Cambridge*, 89:279-293.
7. Davis, J.G., J.R. Blake, and C.M. Woodall (1968), "A Survey of the Hygienic Condition of Domestic Dishcloths and Tea Towels," Medical Officer, 120:29.
8. De Wit, J.C., G. Broekhuizen, and E.H. Kampelmacher (1979), "Cross-Contamination During the Preparation of Frozen Chickens in the Kitchen," *Journal of Hygiene*, 83:27.
9. Park, P.K., and D.O. Cliver (1997), "Disinfection of Kitchen Sponges and Dishcloths by Microwave Oven," *Dairy, Food, and Environmental Sanitation*, 17(3):146-149.
10. *Office of Pesticides Program DIS/TSS Documents* (1992), DIS/TSS-10, Washington, D.C.: U.S. Environmental Protection Agency.
11. Scott, E., and S.F. Bloomfield (1990), "Investigations of the Effectiveness of Detergent Washing, Drying, and Chemical Disinfection on Contamination of Cleaning Cloths," *Journal of Applied Bacteriology*, 68:279-283.
12. McNeil, E., and E.A. Choper (1962), "Disinfectant in Home Laundering," *Soap and Chemical Specialties*, 38:122-128.
13. Jordan, W.E., D.V. Jones, and M. Klein (1969), "Antiviral Effectiveness of Chlorine Bleach in Household Laundry Use," *American Journal of Diseases of Children*, 117:313-316.
14. Buford, L.E., P.A. Hartman, and M.S. Pickett (1977), "Sanitation in Self-Service Automatic Washers," *Applied Environmental Microbiology*, 33:74-78.
15. Lee, M. (1996), "Application of 'Sponge Model' with Disinfectants for the Inhibition of *Listeria monocytogenes*," *Journal of the Korean Fisheries Society*, 29:595-602.
16. Roessler, P.F., and A. Hoyt (1997), "The Bacterial Quality of Domestic Kitchen Cellulose Sponges," *Abstracts of the 97th General Meeting of the American Society for Microbiology*, 97:505.
17. Parnes, C.A. (1997), "Efficacy of Sodium Hypochlorite Bleach and 'Alternate' Products," *Journal of Environmental Health*, 59(6):14-19.