

## **Bacteria in Household Sponges: A study testing which physical methods are most effective in decontaminating kitchen sponges**

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### **Abstract**

This study was undertaken to determine the effectiveness of various physical methods for decontaminating kitchen sponges. Sponges were distributed to participants to be used in the home on a daily basis, after which time they were collected for analysis. Bacterial concentrations were determined using the spectrophotometer. A sample from each sponge was submerged in nutrient broth, and incubated for 48 hours at 37°C. Once the samples had been incubated the nutrient broth was tested for optical density. The sponges were then cleaned using several physical tests, which included microwaving at 30 or 60 seconds, boiling, dishwashing, and washing in the washing machine. The dishwasher had the largest bacterial reduction, reducing bacteria by 57.3%, followed by boiling, with an average bacterial reduction of 47.2%, and the washing machine with an average bacterial reduction of 43.2%. Thirty seconds and 60 seconds of microwaving had no statistically significant reduction compared to the uncleaned control. The results of my study suggested that high temperature in combination with washing is more effective in reducing bacteria in kitchen sponges than using heat alone.

### **Introduction**

Kitchen sponges offer an ideal place for harmful bacteria and other pathogens, such as viruses, to grow. Some of these pathogens include *Escherichia coli*, *Salmonella*, *Klebsiella pneumoniae*, and *Enterobacter cloacae* (Ikawa and Rossen, 1999). There have been many questions as to which methods of cleaning and disinfecting sponges are the most effective. Sponges are commonly used in kitchens around the world to clean surfaces such as cutting boards, pots and pans, dishes, countertops, sinks, refrigerators, faucet handles, and stovetops (Ikawa and Rossen, 1999). Using sponges to clean surfaces, which may be covered with harmful bacteria, and then using them to clean things such as dishes and faucet handles, may allow the bacteria to spread to places where we can come in direct contact with them.

According to Ikawa and Rossen (1999), each year there are an estimated 5.5

to 6.5 million cases of food poisoning reported in the United States. Sponges, which may contain a large amount of pathogens, are a common way for bacteria and other food-borne pathogens, such as *Salmonella* and *E. coli*, to be spread throughout the kitchen. If the sponges are adequately cleaned, the spread of pathogens from kitchen surfaces and sponges to humans may be greatly reduced. Ikawa and Rossen (1999) tested both chemical and physical treatments for decontaminating kitchen sponges. Methods included chemicals such as bleach, hydrogen peroxide, isopropyl alcohol, all purpose cleaner, ammonia, and distilled vinegar, as well as physical methods which included the washing machine, dishwasher, boiling and the microwave oven. To be an effective method for cleaning a sponge, it had to reduce bacteria in the sponge by at least 99.9%. In the first part of the study the

sponges were rinsed and then contaminated with the laboratory grown bacteria to simulate a used sponge. The sponges were then cleaned using the various physical and chemical methods. They then tested the same methods using sponges that were used by consumers in their own home. In the laboratory, the results were much clearer than when they were testing sponges used by consumers, due partially to the fact that they had a consistent sample of types of bacteria in the laboratory. They also speculated that their unclear results may be due to the bacteria in the consumer sponges being more resistant to treatments than the laboratory grown bacteria. The only conclusion was that the treatments which were determined to be effective in laboratory studies could be used to decrease the amount of bacteria in household sponges and would help in reducing cross contamination. No results were definitive when it came to decontaminating sponges that contained resistant bacteria. This study showed the effectiveness of some physical treatments, but did not address which methods would be most useful in a typical household setting as opposed to the laboratory (Ikawa and Rossen, 1999).

According to Kusumaningrum *et al.* (2002), exposure to pathogens may occur by either indirect contact with contaminated objects, or indirectly, through airborne particles. They also indicated that some bacteria, such as *E. coli*, *Staphylococcus aureus*, and *Salmonella*, could survive on hands, sponges and other objects for up to several days after contact. This study tested the ability of certain bacteria to survive on stainless steel surfaces and began by preparing two different stainless steel surfaces, one that was 20 x 20 cm<sup>2</sup> for bacteria survival tests, and the other was 50 x 80 cm<sup>2</sup> for cross-contamination tests. The surfaces were washed and sanitized, using hypochlorite solution to disinfect and hot

water with detergent to rinse, before the tests were conducted. After obtaining cultures from the National Institute of Public Health and The Environment and also from Difco Laboratories, the cultures were maintained at 80° C in vials. From these cultures, suspensions were made and three different contamination levels were prepared. The two surfaces were contaminated to a measurable concentration and were then sampled immediately afterwards to test which pathogens could be recovered. The transfer rates of pathogens on surfaces to the sponges were then tested. In this study, they found that some of the antibacterial dishwashing liquids tested reduced bacteria by 99.999% in that laboratory. However they also stated that there was no evidence to support that the same dishwashing detergents would be effective in a typical household situation, due to the higher resistance to treatments shown by bacteria in the common kitchen. The sponges that were tested in households were shown to collect a large number of bacteria within the first three days of use, after which time the amounts did not increase, as the sponges had reached their maximal loads. The sponges were tested with both regular and antibacterial products to see if either significantly reduced bacteria. None of the products used proved to be effective in eliminating bacteria found in household sponges (Kusumaningrum *et al.*, 2002).

In a study by Mattick *et. al* (2002) the survival of *Salmonella*, *Campylobacter* and *E. coli* was tested. The study examined variables such as hard or soft water, the use of detergent, and survival during drying. Dishes were soiled with bacteria and were then washed in a bowl of warm water with detergent. The study also examined the possibility of cross-contamination onto sterile dishes, sponges, counter tops, and items placed on contaminated surfaces from dirty water. These tests found hard water did

not affect the survival of *E. coli*, and for the most part, *Salmonella* survived towel or air-drying on dishes. During towel drying, contaminants were transferred to the cloth during every test, regardless of the organisms present. It was also found that pathogens were commonly transferred to sterile dishes from the contaminated dishes, although it was rare that they were then transferred to food. The transfer of contaminants to sponges, on the other hand, was a much more common occurrence. This study showed that the transfer of pathogens from contaminated dishwater onto sponges, and then onto countertops and dishes is possible (Mattick *et. al*, 2002).

Nielsen *et. al*, (2002) tested sponges to determine the effect of dishwashing liquid on the bacteria growing in sponges. The sponges were first cleaned of the preservatives found in the sponges upon purchase, as these preservatives prevent growth. These preservatives are washed out of the sponge within a couple of uses in a typical kitchen. The organisms that were used to make the inoculum were 2 species of gram positive bacteria, 4 species of gram negative bacteria, and 1 species of yeast. The dried, rinsed sponges were placed into a bag with deionized water and inoculum. The sponges were mixed by hand to ensure that they were mixed thoroughly with inoculum. A sample was taken from the bags to determine the initial quantity of inoculum and excess water was squeezed from the sponges before they were treated with detergent. To simulate conditions in a typical home, organic matter was added to the sponges to act as a food source for the bacteria. Once prepared, the recommended amount of hand dishwashing detergent was added to the bags containing the sponges, which was then mixed by hand. The inoculated sponges were allowed to dry at room temperature overnight. The next day, the sponges were rehydrated with deionized

water, and samples were taken and swabbed onto a Petri dish, which was incubated for twenty-four hours. The levels of bacteria were determined using a laser counter or colony counter. The tests showed that the dish drops formulation used at 5ml per sponge reduced microbial populations by 99.99%, whereas commercial products reduced populations by 99.90%. The bacteria in the untreated control sponges survived the washing, showing that there was a great difference in the reduction of bacteria when a detergent was used. Antibacterial hand soap only reduced bacteria by 33.9%, and the antibacterial sponge only reduced bacteria by 45.1%; these results were not significantly different from the control (Nielsen *et. al*, 2002).

Kusumaningrum *et. al* (2001) examined the use of dishwashing detergents as an aid to killing pathogens commonly found in the kitchen, such as *E. coli*, *Salmonella*, *S. aureus*, and *Bacillus cereus*. This study tested detergents with and without food residue present. The study began by obtaining 6 new sponges and dishwashing detergents from a local supermarket. Used sponges were also obtained from earlier laboratory experiments on the survival of pathogens in new sponges. The used sponges were washed in hot water with an antibacterial dishwashing liquid and then allowed to air dry before being stored at room temperature for 1 to 2 weeks. The six new sponges were contaminated with the bacteria suspensions and were stored at room temperature, and were tested for bacterial concentrations on various days. The main difference between this study and the study done by Nielsen *et. al* (2002), is part of this study was actually conducted in households to test the efficiency of antibacterial dishwashing liquid used by the consumers. The importance of this study was to determine how detergents increase the effectiveness of physical methods of

decontaminating sponges. This study considered the differences between bacteria grown in the laboratory and the bacteria that is actually found in consumer homes. All of the organisms tested showed rapid growth in laboratory conditions; except *S. aureus* and *B. cereus* both decreased in number below detection levels in reaction to low concentrations of dishwashing detergents in test suspensions. *E. coli* and *Salmonella* maintained their concentrations for up to twenty-four hours after being exposed to the detergents. After 24 hours concentrations of all the bacteria began to decrease. The sponges that were used in consumer homes on a daily basis came in contact with detergents at least once a day, and showed no dramatic decrease in bacteria. The consumer sponges were tested both with antibacterial and regular dishwashing soaps over a two week study. This study found that some brands of dishwashing detergents are effective in reducing bacteria in test suspensions, but none were effective in used sponges. This study evaluated how detergents can make a difference in the effectiveness of dishwashing machines (Kusumanungrum *et. al.*, 2001).

In the study I conducted, 48 used sponges were tested to determine the initial bacterial concentrations in them. After initial bacterial counts were established, different decontaminating methods (heating in the microwave, boiling, washing in the dishwasher, and washing in the washing machine) were performed. Unlike the other studies, my study focused on testing only physical methods for decontaminating household sponges. The sponges that I used in this experiment were used by consumers in their own homes; I did not do testing on bacteria grown in the laboratory, as the strains may differ from those found in the home.

My main objective was to determine if there is an effective physical method to

clean and rid sponges of bacteria, some of which could be harmful or pathogenic. I tested bacteria found in sponges used in actual homes, as apposed to laboratory grown bacteria, as bacteria found in the home seems to be more resistant to treatment. In this experiment, I expected that the methods of treatment that exposed the sponges to the highest temperatures would be the most effective in decontamination. I believed that the microwave would produce the highest temperatures and would therefore be the most effective method.

## Methods

I began this study by obtaining 70 synthetic sponges with green scrubber pads on one side and distributed them to my participants, which included classmates and coworkers. The sponges that I used did not contain any anti-bacterial preservatives; therefore all I did to prepare the sponges was remove them from the packages and distribute one sponge into each numbered zip lock bag. Once the participants received their sponges, they were instructed to use the sponges as they typically would on a regular basis using no methods of cleaning, other than rinsing, when done using the sponge.

After two weeks, the sponges were collected from the participants and taken back to the laboratory for testing. As anticipated, not all of the sponges were returned in time to be included in the study, because of which the sample size for each test had to be reduced from 10 sponges to 8 sponges. The control group underwent the same tests to determine initial bacteria concentrations as the other groups did, but were then allowed to sit at room temperature (about 25°C), while the other groups underwent the physical cleaning tests. All sponges were allowed to sit at room temperature for 48 hours to simulate a sponge that had been sitting out on the

counter before undergoing any treatment. To determine initial bacterial concentrations I punched a hole, about 1mm in diameter, in each sponge using a cork borer, which is designed to punch holes in corks. The sponges were then returned to their sealed bags to incubate at room temperature. The circle cut out from each sponge was placed into a test tube containing 4ml of sterilized nutrient broth. The nutrient broth was made with 4.8g of BioPro Premium Nutrient Broth (concentrated beef extract and concentrated Bio-Gel Peptone) per 600ml of deionized water. The nutrient broth was then autoclaved in a Barnstead 14-48823 autoclave for 20 minutes at 121°C. The tubes were allowed to incubate at 37°C for 48 hours to allow adequate time for bacterial growth. A test tube with sterile broth that was allowed to incubate with the other tubes was used as a blank to set the spectrophotometer. The spectrophotometer used was the Spectronic 20 by Bausch and Lomb and was set at a wavelength of 686nm. The broth from each tube containing a sponge cutout was then decanted into a cuvette and the percent transmittance was measured using the spectrophotometer. The percent transmittance was then used to calculate the optical densities (O.D.) of bacteria in the sponges using the formula:  $O.D. = (100/\%T)$ . After determining the initial bacteria concentrations, I began treating the sponges with the various physical methods of treatment.

Each of the 5 test groups and the control group contained 8 sponges. The control sponges did not undergo any physical cleaning treatments other than a simple hand washing with warm water at the end of the two-week period. The control sponges were left in airtight containers while the other groups of sponges were being tested, then they were tested once more for final bacteria concentrations. The first method of treatment was the use of the

microwave. Two groups of sponges were microwaved in a GE Turntable microwave with a power of 1550 watts: one group for 30 seconds and one group for 60 seconds to determine if the amount of time a sponge is microwaved effected the results of the treatment. The sponges were individually removed from their containers and microwaved one at a time, making certain that the sponges were kept moist with distilled water at all times to prevent the sponges from igniting in the microwave (Ikawa and Rossen, 1999). After 8 sponges for each time increment were treated, they were then cooled and set aside in new, clean airtight containers until being tested for final bacteria counts. The third group of sponges that was treated was boiled for 10 minutes in regular tap water in Lacey, Washington. These sponges were also set aside for further testing after allowing some of the excess water to drip out of the sponge and after cooling.

The final two groups of sponges were treated using the washing machine and the dishwasher. For the washing machine, each of the sponges was washed alone in the washing machine with detergent on the hot cycle. The detergent I used was the Kirkland Signature Fresh and Clean Scent Ultra Laundry Detergent. I ran the tests using detergent, as it is common to include a detergent when using a washing machine. For the dishwasher, 4 sponges were loaded on the top rack and 4 on the bottom rack of a Hotpoint dishwasher set on the normal wash at high temperature. Dishwashing detergent was also used in this treatment. For the dishwasher, the brand detergent I used was Safeway Lemon Scented Gel Dishwasher detergent.

After the treatments, the sponges were tested for concentrations of bacteria. All of the sponges which had undergone treatment and the control sponges were tested for bacterial concentrations. A hole

was punched out of the sponges making certain that the hole was in the same region of the sponge as the first. The cut-out was then submerged in a test tube containing 4ml of nutrient broth and allowed to incubate at 37°C for 48 hours. The broth was then pipetted into a cuvette and was run through the spectrophotometer to determine the optical density of bacteria in the sponges. From the initial and final concentrations, I calculated the percent reduction to determine the effectiveness of each treatment. Using the program Minitab, a one way analysis of variance (ANOVA) was conducted to calculate P-values. After P-values were determined, Tukey tests were performed to compare the effectiveness of each treatment against each other and the control.

## Results

The results of my experiment showed that boiling, dishwashing, and the use of the washing machine were the only methods of treatment that were statistically significantly different than the control group, which did not undergo any treatment. In contrast, the microwave at both 30 seconds and 60 seconds showed no significant difference from the control. Since the control group did not undergo any treatment, it appears as though the microwave had the same effect on the sponge as if they had not been treated at all.

A one way ANOVA showed that the sponges before treatment were not statistically significantly different from one another, meaning that they were all equally contaminated before undergoing any treatments (D.f=5, F=2.10, and P=.084 ). Figure 1 shows that there was a reduction in bacteria by all treatments, even the control.

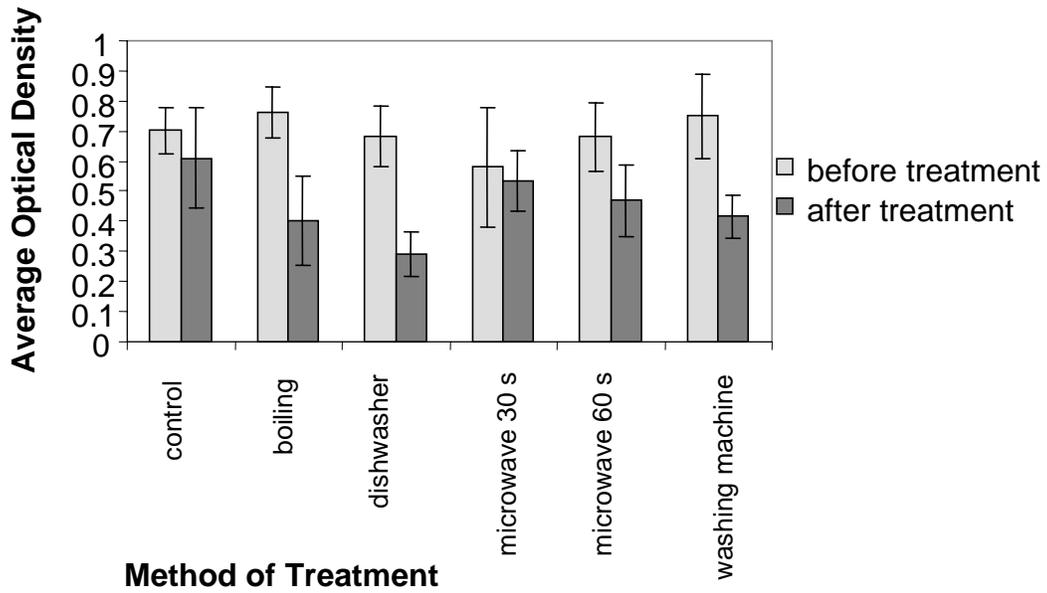


Figure 1: Comparison of optical densities before and after treating contaminated kitchen sponges. Averages with standard deviation error bars for before and after each treatment, with each treatment group containing 8 sponges.

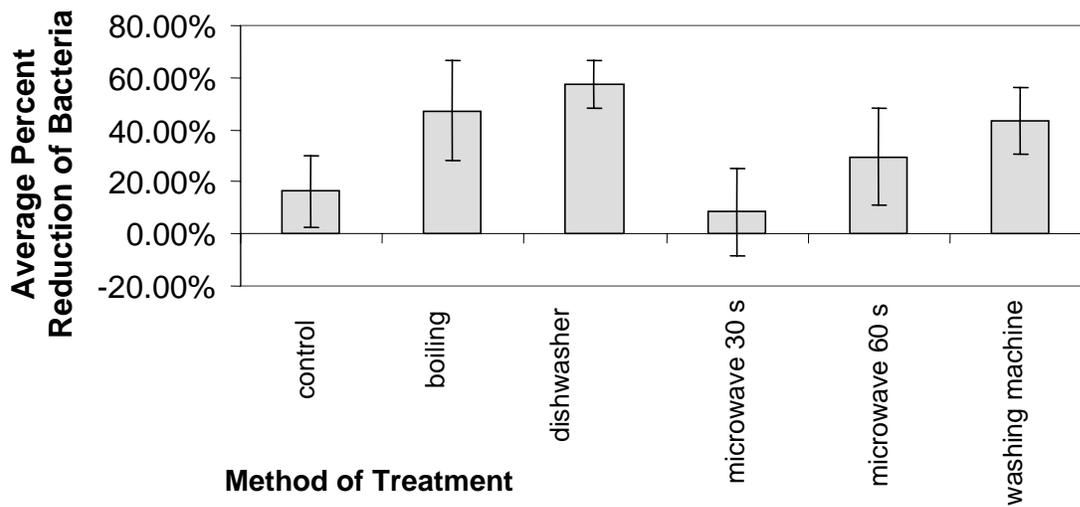


Figure 2: The effectiveness of various physical methods for decontaminating kitchen sponges, for sample sizes of 8 sponges per treatment. Shown are average percent reductions of bacteria for each physical treatment with error bars of one standard deviation about the mean.

In particular, the dishwasher produced the greatest difference after having undergone treatment. The dishwasher had a mean percent reduction of 57.3%, meaning that it had the lowest bacterial concentrations after treatment.

A one way ANOVA test showed that the sponges after treatment were statistically significantly different from each other, so a Tukey test was used to determine which methods were different from the control. The sponges that had gone through the physical treatments were statistically different ( $P < 0.0001$ ). This showed that the methods of treatment did have some effect on the sponges, reducing the bacteria. The results from the Tukey test showed that microwaving for 30 seconds and microwaving for 60 seconds were the only two methods that were not statistically different than the control (Individual confidence level 99.53%).

As shown in Figures 1 and 2, dishwashing the sponges showed the biggest difference in before means compared to means after treatment (mean difference = 0.3917). Next after that was boiling with a mean difference of 0.3599, the washing machine produced a mean difference of 0.3348, microwaving for 60 seconds had a mean difference of 0.2113, and microwaving for 30 seconds had a mean difference of 0.0456. The mean difference of the control group was 0.0911.

Out of the methods tested, the best in cleaning the sponges was the dishwasher, which reduced bacteria by 57.3%, after which was boiling which reduced bacteria by 47.2%. The washing machine was the only other method that was statistically different than the control, with a bacterial reduction of 43.2% (Figure 1 and 2). Microwaving at 30 seconds had a mean reduction of 8.4%, and the microwave at 60 seconds had a bacterial reduction of 29.7%.

The microwave treatments were not statistically significantly different from the control (Figures 1 and 2).

### **Discussion**

I expected the microwave to be the most effective method, as I believed it would expose the sponges to highest temperatures. The results of this experiment failed to support this hypothesis, as the dishwasher was found to be the most effective method reducing bacteria by 57.7%. Rather than the microwave, the methods that physically washed the sponges were the methods that eliminated the most bacteria.

Since the dishwasher was found to be the most effective method, it is possible that washing the sponges while exposing them to extreme heat is the most effective way to remove bacteria from kitchen sponges. This would be a good hypothesis to test in future studies with larger sample sizes. I speculate that the water in the dishwasher was very hot when it reached the inside of the sponge, killing and then rinsing away the bacteria, while the microwave left behind plenty of bacteria. Since a detergent was added in both the dishwasher and the washing machine, the detergent itself could have played a significant role in reducing bacteria in the sponges. It is possible that in the microwave tests, the sponges were heated but none of the contaminants were removed, such as hairs or food particles, which gave the bacteria in the sponges nourishment so that they could continue multiplying. The lack of microwave cleaning effectiveness may have also been affected by the nature of the sponges. The sponges were about one inch in thickness and were very porous, which may have provided protection for the bacteria in the center of the sponges. I did not test the temperatures of the sponges to see if the interior reached the same temperatures as

the exterior of the sponges, this would be a good factor to consider in a future study.

If I were to do this experiment again, I would like to test the temperatures that are

being reached in the sponges during each treatment so that I can analyze if there is a correlation between the temperatures reached and the amount of bacteria that is killed. I had assumed that the microwave produced the highest temperatures and would therefore be the most effective method. A test measuring the temperatures reached in the sponges for each method of treatment would need to be conducted before testing those methods for effectiveness so that an accurate correlation could be made between the temperatures reached and the amount of bacteria killed. The main difference between what I have already done and what I would do in a future study is to look further into what combination of treatments work the best. For example, I would further test heat and washing in combination. I would also like to test how much of an impact the detergents had on the effectiveness of the washing machine and the dishwasher.

An addition to testing whether extreme heat alone is effective or if washing with extreme heat is more effective in removing bacteria from kitchen sponges, I would like to test the effectiveness of UV rays to kill bacteria in sponges. Ultra violet radiation is used in hospitals to sterilize instruments and other equipment, so it may work in sterilizing sponges. I would like to test both UV rays alone and the use of UV rays in combination with other methods of cleaning to see if it increases the effectiveness of those methods.

While I found that some of the methods tested for cleaning sponges reduced the amount of bacteria in the sponges, I did not find a method that fit the criteria for

being an effective method, meaning that it reduced bacteria by 99.9%. Since none of my methods reduced enough bacteria to be considered effective, I would recommend that if you are going to use a sponge to clean surfaces in the kitchen it would be best to clean the counters with a disinfectant after wiping then down with the sponge. The best course of action may be to limit the length of time a sponge is used or to eliminate the use of sponges in the kitchen altogether.

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### Literature Cited

- Bradford M.A., Humphrey T.J., Lappin-Scott H.M.** 1996. The Cross-Contamination and Survival of *Salmonella enteritidis* PT4 on Sterile and Non-Sterile Foodstuffs. *Journal of Applied Microbiology* 24: 261-264
- Brown A.E.** 2005. *Benson's Microbiological Applications: Laboratory Manual in General Microbiology*, Ninth Edition. McGraw-Hill companies, Inc.

**Ikawa, J. Rossen, J.** 1999. Reducing Bacteria in Household Sponges. *Journal of Environmental Health* 18-22.

**Josephson K.L., Rubino J.R., Pepper I.L.** 1997. Characterization and Quantification of Bacterial Pathogens and Indicator Organisms in Household Kitchens with and without The Use of Disinfectant Cleaner. *Journal of Applied Microbiology* 83: 737-750.

**Kusumaningrum H.D., Riboldi G., Hazeleger W.C, Beumer R.R.** 2002. Survival of Foodborne Pathogens on Stainless Steel Surfaces and Cross-Contamination to Foods. *International Journal of Food Microbiology* 85: 227-236.

**Kusumaningrum H.D., Putten M.M., Rombouts F.M. Buemer R.R.** 2001. Effects of Antibacterial Dishwashing Liquid on Foodborne Pathogens and Competitive Microorganisms in Kitchen Sponges. *Journal of Food Protection* 65: 61-65.

**Mattick K., Durham K, Domingue G., Jorgensen F., Sen M., Schaffner D., Humphrey T.** 2002. The Survival of Foodborne Pathogens during Domestic Washing-up and Subsequent Transfer onto Washing-up Sponges, Kitchen Surfaces and Food. *International Journal of Food Microbiology* 85: 213-226.

**Nielsen P., Brumbaugh E., Kananen L.** 2002. Evaluation of the Use of Liquid Dishwashing Compounds to Control Bacteria in Kitchen Sponges. *Journal of AOAC International* 85: 107-112.