Food Protection Trends, Vol. 26, No. 11, Pages

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Identity and Numbers of Bacteria Present on Tabletops and in Dishcloths Used to Wipe Down Tabletops in Public Restaurants and Bars

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SUMMARY

Dishcloths used in restaurants and bars (23 restaurant cloths, 14 bar cloths) were collected, and tabletops (10 restaurants) were swabbed, to determine the occurrence of bacteria. Coliforms were isolated from 89.2% of dishcloths and 70% of tabletops. *Escherichia coli* was isolated from 54.1% of dishcloths and 20% of tabletops. The numbers of heterotrophic plate count bacteria (HPC) and coliforms were significantly higher in bars than in restaurants. The levels of HPC found in dishcloths were 25-fold and coliforms were 60- to 120-fold lower than the levels found in home dishcloths reported in previous studies. The numbers recovered from restaurant tabletops were also lower than those from household kitchen countertops. The most commonly isolated genera from dishcloths in restaurants and bars differed from those in homes. The numbers found for HPC on restaurant tabletops were 45-fold greater after cleaning than prior to cleaning. There were also a 19-fold greater number of coliforms and twice as many *E. coli*. Therefore, although the mandatory use of sanitizers in restaurants and bars may have reduced contamination levels and caused a shift in the microbial populations present in food service establishments, the implication of dishcloths in contamination of tabletops through cleaning suggests that current monitoring of linen sanitation solutions might be inadequate.

A peer-reviewed article

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INTRODUCTION

In the United States each year, an estimated 76 million cases of foodborne gastroenteritis occur, with 325,000 hospitalizations and 5,194 deaths *(10)*. The microbial causes of foodborne illness include viruses, bacteria and parasites, with symptoms ranging from mild gastroenteritis to life-threatening neurologic, hepatic, and renal disease *(10)*. Because food is transported to consumers through long chains of industrial production, processing and distribution, numerous circumstances allow for contamination along the way, and existing regulations may not be sufficient to prevent illness. It is helpful to understand the mechanisms by which such contamination occurs in order to reduce the risk of foodborne illnesses *(16)*.

Epidemiological surveillance is important in determining the types of foods responsible in outbreaks, the populations at risk, the circumstances that lead to food contamination and the growth/survival of foodborne pathogens *(9)*. Data collected by the US Food and Drug Administration (FDA) from nearly 900 institutional food service establishments, restaurants, and retail food stores identified improper hold-

ing times and temperatures, contaminated equipment/cross contamination, inadequate cooking and poor personal hygiene as risk factors for foodborne disease *(7)*. Between 1988 and 1997, restaurants (2,158) were the most significant sources of foodborne outbreaks, followed by residences (1,032) *(2, 11)*.

When contaminated cloths come into contact with fingers or surfaces, microorganisms are readily transferred. This may represent a risk if there is subsequent contact with food *(13)*. Studies in domestic kitchens indicate that wet cloths are important elements in such cross contamination *(13)*. In one study, cleaning cloths impregnated with a quaternary ammonium disinfectant were compared to cleaning cloths used with a detergent *(14)*. Some of the cloths used with detergent became heavily contaminated within three hours of use. Following use of these cloths for surface cleaning, both the surfaces and the cloths were more heavily contaminated, which suggests that cross contamination had occurred between cloths and surfaces. After the quaternary ammonium-impregnated cloths were used for cleaning, a significant reduction in contamination on food preparation surfaces and cloths was found *(14)*.

Enriquez et al. *(6)* analyzed sponges and dishcloths from household kitchens in the United States. *Pseudomonas* spp. were the most commonly isolated bacteria. Presumptive *Staphylococcus aureus* and *Salmonella* spp. were isolated, with similar frequencies for cellulose sponges and dishcloths. Several other *Enterobacteriaceae* were also isolated. Total and fecal coliform bacteria were present in large numbers in contaminated cleaning materials, sometimes reaching levels greater than 10^8 colony-forming units (CFU)/ml in liquid samples *(6)*. In a similar study of cellulose and natural fiber sponges (loofahs), *S. aureus*, *Aeromonas* spp., *Pseudomonas* spp. *Enterobacteriaceae* and *Serratia* spp. were identified *(3)*. These findings, as well as the recovery of large numbers of enterobacteria from draining boards *(15)*, sinks and dishcloths in household kitchens *(12, 15)*, suggest that dishcloths may act as both reservoirs and disseminators of microbial contamination *(15)*.

In the current study, the occurrence of heterotrophic plate count (HPC) bacteria, total coliforms and *Escherichia coli* on tabletops and dishcloths (used to wipe down tabletops) in public restaurants and bars was determined. In addition, heterotrophic bacterial isolates were identified. The purpose of this study was to determine if current dishcloth sanitation in restaurants and bars is sufficient to prevent environmental cross contamination and thus the spread of foodborne illnesses in public food service establishments. The microbiological results were also used for comparison with results from previously published household kitchen studies.

METHODS

Sample collection

Cleaning dishcloths (2,025 cm^2 total area) were collected from restaurants and bars in the United States and placed in Ziploc™ plastic bags for transport on ice to the laboratory. Restaurants in the study included fast food chains; bar and grills; and pizza, Mexican and Chinese restaurants located in New York City (NY), San Francisco (CA), and Phoenix, Flagstaff, and Tucson (AZ). Restaurant tabletops were also sampled by swabbing (approximately 156 cm^2 total area) with BBL™ CultureSwabs™ (Becton Dickinson, Franklin Lakes, NJ, USA) for subsequent immediate transport on ice to the laboratory. Members of the restaurant staff were unaware of the study and therefore followed their normal cleaning routine.

Sample processing

Dishcloths were wrung to remove any excess liquid; then 75 to 100 ml (depending on the latent moisture content of the cloth) of Letheen neutralizing broth (Difco Laboratories, Detroit, MI, USA) was added to the dishcloths in the Ziploc™ bags. The bags were squeezed to distribute the neutralizer liquid throughout the cloths. After 5 minutes of manual compression, liquid was wrung from the cloths and collected in sterile tubes.

The tabletop culture swabs were vortexed for 30 seconds; then pliers were used to squeeze the liquid from the swab. This resulted in a sample volume of approximately 0.6 ml. An additional 0.5 ml of Tris-Buffered Saline (TBS; Sigma-Aldrich, St. Louis, MO, USA) was added to bring the final sample volume to 1.1 ml. In a separate experiment, tabletops were swabbed, wiped down with a dishcloth (by the restaurant staff) and then swabbed once again to determine if cleaning the table had affected bacterial numbers. As stated previously, members of the restaurant staff were unaware of the study and therefore followed their normal cleaning routine. The swabs were then processed as described previously.

HPC bacterial numbers were determined by plating out appropriate serial dilutions from the swab and dishcloth liquids in duplicate onto R2A medium (Difco, Sparks, MD, USA), utilizing the spread plate technique. Agar plates were incubated at 30°C for five days; then the bacteria were enumerated by counting colony-forming units (CFU). The number of HPC bacteria per square centimeter was then calculated for each sample.

Total coliforms and *E. coli* were enumerated using Colilert Quanti-Trays™ (IDEXX Laboratories, Inc. Westbrook, ME, USA) as per the manufacturer's instructions.

Species identification

For detection of *Listeria monocytogenes*, 1.0 ml of each dishcloth sample was used to inoculate UVM Modified Listeria Enrichment Broths (Difco Laboratories, Detroit, MI, USA) and incubated for 24 hours at 30°C in a dry heat block. From turbid UVM broth samples, 0.1 ml volumes were transferred to selective enrichment Fraser Broth (Difco Laboratories, Detroit, MI, USA) and incubated at 35°C for 24 to 48 hours. After incubation, 0.1 ml from the esculin-positive samples were placed on the selective chromogenic medium RAPID'L.mono (BIO-RAD, Hercules, CA, USA), using the spread plate technique, and incubated for an additional 24 to 48 hours at 35°C.

Three disparate colonies from each R2A agar plate were also subcultured on Tryptic Soy Agar (TSA; Difco, Sparks, MD, USA) plates, using the streak for isolation method. The pure cultures were then transferred to MacConkey Agar (Difco, Sparks, MD, USA) plates, Gram-stained and further characterized using the oxidase and catalase tests. Isolated colonies from the TSA plates were also resuspended in inoculating fluid (Biolog, Inc. Hayward, CA, USA) to a turbidity approximately equivalent to Biolog turbidity standards and then used to inoculate Biolog MicroPlates™ (Biolog, Inc., Hayward, CA, USA) as per the manufacturer's instructions. The plates were incubated for 24 hours at 35°C. The results were manually analyzed by use of the Biolog MicroLog 1 System (Program Version 4.20).

Statistical analysis

A Student's t-test was used to compare the bacterial counts recovered from dishcloths in restaurants and bars. Geometric means were used to report the results and were utilized in the statistical

FIGURE 1. Bacterial levels found in dishcloths and on tabletops in restaurants and bars

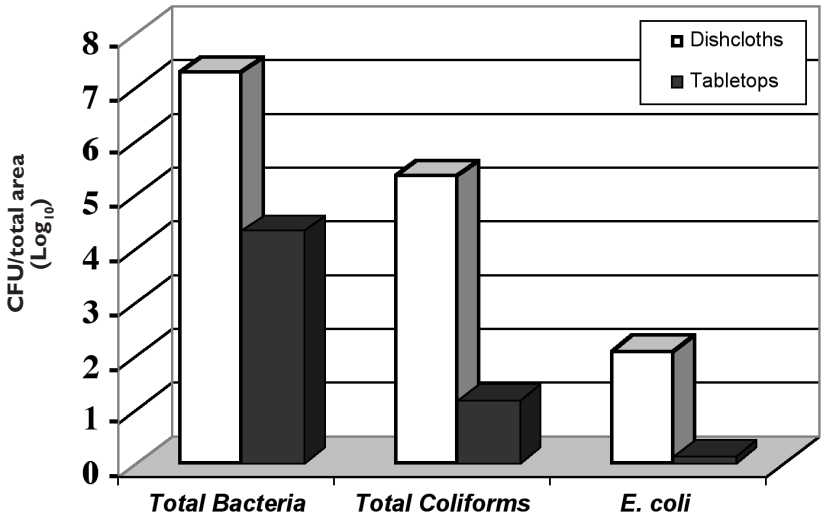


FIGURE 2. Comparison of bacterial levels in dishcloths from restaurants and bars

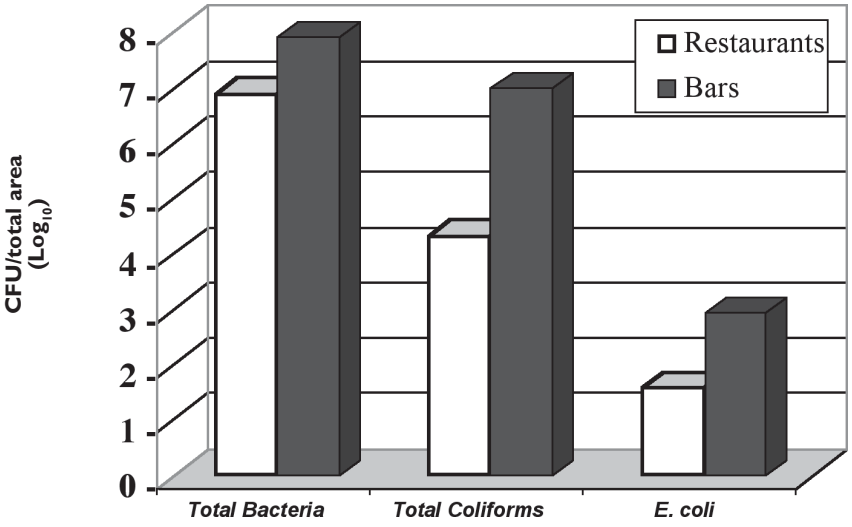
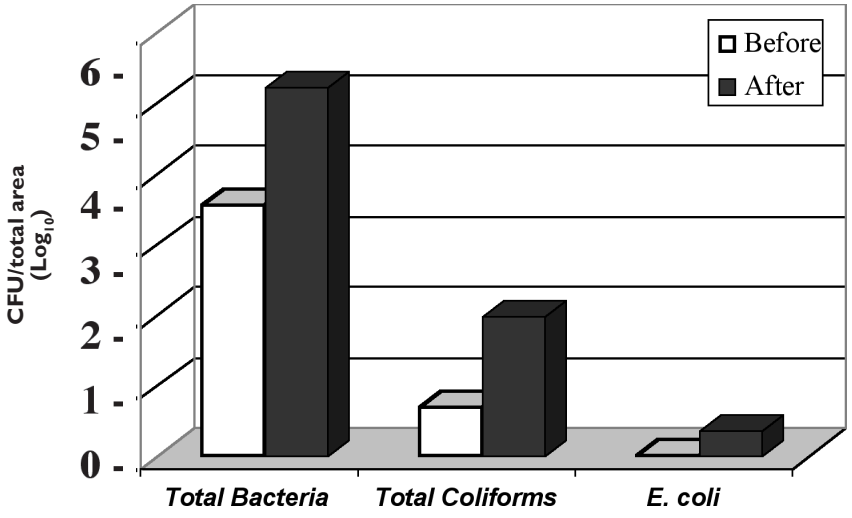


FIGURE 3. Bacteria found on tabletops before and after cleaning in restaurants



analyses. Geometric means were utilized for all bacterial counts because of the presence of outlying data values. Similar studies conducted in household kitchen environments have also employed geometric means *(3, 6, 12)*.

RESULTS

HPC, total coliforms and *E. coli* bacteria

Geometric means (GM) of approximately 1.9×10^7 CFU/cloth of heterotrophic plate count bacteria (range of 8.5×10^2 to 8.5×10^{10}), 2.2×10^5 CFU/cloth of total coliform bacteria (range of 70 to 1.0×10^{11}) and 1.2×10^2 CFU/cloth of *E. coli* (range of 2.3 to 1.1×10^6) were isolated from dishcloths in restaurants and bars (Fig. 1). Total coliforms were found in 89.2% of the dishcloths sampled (7.6×10^5 CFU/cloth) and *E. coli* in 54.1% of dishcloths (1.9×10^3 CFU/cloth).

A geometric mean of 2.2×10^4 CFU for heterotrophic plate count bacteria (range of 8.3×10^2 to 2.4×10^7), 15.0 CFU for total coliform bacteria (range of 1.0 to 1.2×10^7) and 1.4 CFU for *E. coli* (range of 1.0 to 27.0) were isolated from swabs of tabletops in restaurants (Fig. 1). These numbers represent the bacteria found on the entire surface swabbed (approximately 156 cm^2). Total coliforms were found on 70% of tabletops (49.8 CFU/156 cm^2) sampled, and *E. coli* was found on 20% of tabletops (5.2 CFU/156 cm^2).

The levels of bacteria found in dishcloths from bars were higher than those found in dishcloths from restaurants (Fig. 2). In dishcloths from restaurants, there were approximately 7.7×10^6 CFU/cloth of HPC bacteria, 2.1×10^4 CFU/cloth of total coliforms and 3.7×10^1 CFU/cloth of *E. coli*. Figures for dishcloths from bars were approximately 8.7×10^7, 1.0×10^7 and 8.7×10^2 CFU/cloth of total bacteria, total coliforms and *E. coli*, respectively. These differences were significant ($P \leq 0.05$) for HPC bacteria and total coliforms, but not for *E. coli*.

Greater numbers of bacteria were found on tabletops that had been cleaned with a dishcloth than before cleaning (Fig. 3). Approximately 3.56×10^3 CFU/156 cm^2 heterotrophic plate count bacteria were found before cleaning. This number increased to 1.6×10^5 CFU/156 cm^2 (45-fold increase) after the tables had been wiped down with a dishcloth. Likewise, the numbers increased for total coliforms (4.9 to 92.2 CFU/156 cm^2) and *E. coli* (< 1 to 2.3 CFU/156 cm^2) following cleaning.

TABLE 1. Bacterial species isolated from dishcloths in restaurants and bars

Species	# Positive	Frequency (%)
Listeria inocua	9/37	24.3
Raoultella (Klebsiella) terrigena	7/37	18.9
Pseudomonas macuicola	6/37	16.2
Pseudomonas putida	6/37	16.2
Pseudomonas fluorescens	3/37	8.1
Ralstonia (Pseudomonas) pickettii	3/37	8.1
Enterobacter cloacae	3/37	8.1
Enterobacter agglomerans	2/37	5.4
Ralstonia (Pseudomonas) solanacearum	2/37	5.4
Cellulomonas hominis	2/37	5.4
Stenotrophomonas maltophilia	2/37	5.4
Acinetobacter calcoaceticus	2/37	5.4
Pseudomonas syringae	1/37	2.7
Klebsiella oxytoca	1/37	2.7
Klebsiella pneumoniae	1/37	2.7
Klebsiella spp.	1/37	2.7
Enterobacter aerogenes	1/37	2.7
Enterobacter asburiae	1/37	2.7
Enterobacter sakazakii	1/37	2.7
Staphylococcus aureus	1/37	2.7
Staphylococcus piscifermentans	1/37	2.7
Staphylococcus sciuri	1/37	2.7
Staphylococcus wameri	1/37	2.7
Serratia marcescens	1/37	2.7
Serratia rubidaea	1/37	2.7
Kluyvera ascorbata	1/37	2.7
Kluyvera cryocrescens	1/37	2.7
Microbacterium arborescens	1/37	2.7
Microbacterium testaceum	1/37	2.7
Aeromonas veronii	1/37	2.7
Bacillus mycoides	1/37	2.7
Bacillus subtillis	1/37	2.7
Brevundimonas vesicularis	1/37	2.7
Buttauxella izardii	1/37	2.7
Chryseobacterium gleum	1/37	2.7
Comamonas terrigena	1/37	2.7
Corynebacterium thomssenii	1/37	2.7
Dermobacter hominis	1/37	2.7
Escherichia vulneris	1/37	2.7
Herbaspirillum seropedicae	1/37	2.7
Pantoea punctata	1/37	2.7
Paucimonas lemoignei	1/37	2.7
Rhanella aquatilis	1/37	2.7
Roseomonas genomospecies	1/37	2.7

TABLE 2. Frequency (%) of most commonly isolated bacterial species in dishcloths/cleaning utensils

Species	Restaurants and bars[a]	Household Kitchens	
		Study 1[b]	Study 2[c]
***Pseudomonas* spp.**	56.8	31.0 – 38.1	31.8
***Enterobacter* spp.**	21.6	14.3 – 20.7	4.8
***Klebsiella* spp.**	27.0	0	0
***Listeria* spp.**	24.3	ND[d]	ND[d]
***Salmonella* spp.**	0	13.8 – 15.4	9.8
Staphylococcus aureus	2.7	18.6 – 20.0	> 60.0
Aeromonas hydrophila	0	0	19.5

a – present study included only dishcloths

b – study included both dishcloths and sponges (Enriquez et al. 1997b)

c – study included both sponges and loofahs (Chaidez and Gerba 2000)

d – presence not determined

TABLE 3. FDA approved chemical dishcloth sanitizers for food service establishments

Sanitizer	Concentration (mg/L)	Time (sec.)	Temperature (˚C)	pH	Water Hardness (mg/L)
Iodine	12.5 to 25	30	≥ 24	≤ 5[a]	N/A
Chlorine[b]	25	7	49	≤ 10	N/A
	50	7	24	≤ 8	N/A
	50	7	38	10	N/A
	100	10	13	≤ 10	N/A
Quaternary Ammonium Compounds	200	30	≥ 24	N/A	≤ 500

a – or a pH no higher than the level for which the manufacturer specifies the solution is effective

b – any of the four sets of conditions specified may be used

N/A – not applicable

Bacterial species identification

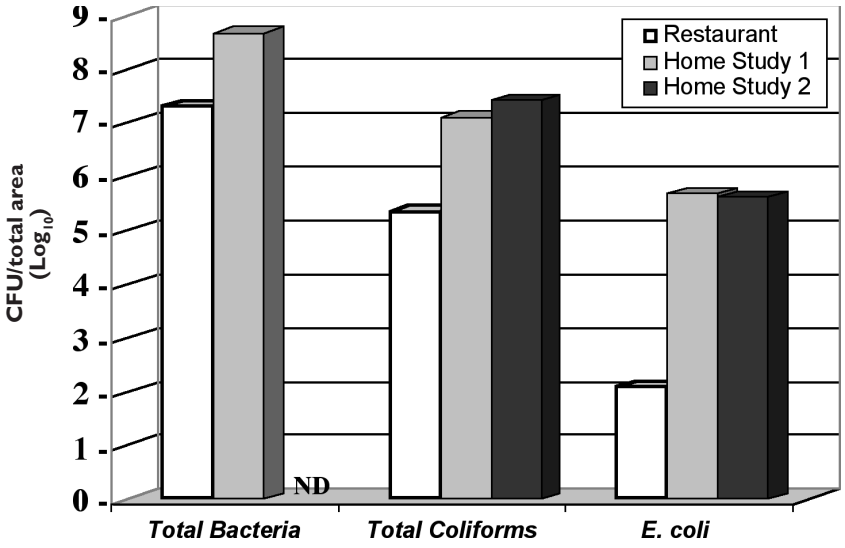
No isolates of *Listeria monocytogenes* were recovered from dishcloths (0/37) in restaurants and bars; however, *Listeria inocua* was found in 9/37 dishcloths (24.3%). A list of bacterial species recovered from dishcloths is shown in Table 1. The other most commonly isolated species were *Raoultella* (*Klebsiella*) *terrigena* (18.9% frequency), *Pseudomonas macuicola* (16.2%), *Pseudomonas putida* (16.2%), *Pseudomonas fluorescens* (8.1%), *Ralstonia* (*Pseudomonas*) *pickettii* (8.1%) and *Enterobacter cloacae* (8.1%).

The most common genera isolated (Table 2) were *Pseudomonas* (6 species, 21 isolates, 56.8% frequency), *Klebsiella* (4 species, 10 isolates, 27.0% frequency), *Listeria* (1 species, 9 isolates, 24.3% frequency), *Enterobacter* (5 species, 8 isolates, 21.6% frequency) and *Staphylococcus* (4 species, 4 isolates, 10.8% frequency). *Staphylococcus aureus* was found in 1/37 dishcloths (2.7% frequency).

DISCUSSION

Self-disinfecting sponges, which are colonized by lower numbers of bacteria in comparison to regular sponges, reduce the transfer of total and fecal coliform bacteria to surfaces and to hands *(5)*. Self-disinfecting cloths are often improperly

FIGURE 4. Comparison of bacterial levels[a] in dishcloths from restaurants/bars and homes[b]



a – The number of *E. coli* found in restaurants/bars was compared to the number of fecal coliforms in homes

b – Study 1 (Rusin et al. 1998); Study 2 (Enriquez et al. 1997b)

ND – not determined

used, causing neutralization of the disinfectant *(14)*. The use of self-disinfecting cloths is therefore not likely to be a viable option for public food service establishments.

The FDA-approved chemical sanitizers for linens in restaurants and bars, and the specific conditions for their use, are listed in Table 3. Other sanitizers are also allowed so long as they are used in accordance with the manufacturer's use directions included in the labeling *(1)*. The purpose of these sanitizer solutions is to sanitize the cloths after they have been contaminated through use. Sanitization is the cumulative effect of treatments that results in at least a 5-$\log_{10}$ (99.999%) reduction in representative disease microorganisms of public health importance *(1)*. The FDA's federal food code recommends that linens used in restaurants and bars to wipe down food service areas be soaked in one of these approved sanitizers under the conditions specified in Table 3 *(1)*. As of September 2004, the federal food code had been adopted by 45 states and one territory and was in the process of being adopted by several others. The FDA's recommendations have therefore been mandated by regulatory agencies in most states *(1)*.

As soiled cloths are added to the sanitizing liquid, organic material in the cloths creates a demand on the sanitizer itself. It may also cause changes in pH and water hardness that will decrease the sanitizer's effectiveness or even neutralize the solution. The sanitizing solution should therefore be checked regularly and replenished/refreshed. The temperature of the sanitizing solution may also drop below the recommended minimum, thereby reducing its efficacy. Food service establishments often do not routinely monitor the quality of the sanitizer dip during use, and restaurants and bars therefore often fail to meet these sanitization criteria.

In the present study, bacterial levels found in dishcloths from bars were consistently higher than dishcloths used in restaurants. One possible explanation is that cloths from bars do not become visibly soiled as quickly as those from restaurants and therefore are not sanitized as frequently. Also, workers in bars are perhaps less aware or concerned about the need for proper sanitation of cloths than are restaurant workers. Cloths in bars are usually used to wipe up liquid spills rather than foods. If they are not sanitized as frequently because of lack of visible soiling and/or worker complacency, this provides a moist environment in which bacteria are able to survive for extended periods *(4, 8)*.

The levels of heterotrophic bacteria, total coliforms and *E. coli* found in dishcloths from restaurants and bars were compared to levels found in dishcloths in homes, as reported in previous studies (Fig. 4). The number of HPC bacteria was approximately 25-fold lower in dishcloths from restaurants and bars than in those from homes *(12)*. Likewise, the number of total coliforms was approximately 60- to 120-fold lower in dishcloths from restaurants/bars *(6, 12)*. The number of *E. coli* was also significantly (3,400- to 4,000-fold) lower (in comparison to the number of fecal coliforms) *(6, 12)*. The number of *E. coli* would be expected to be lower than the number of fecal coliforms present; however, the other differences between HPC and coliform bacterial counts could be due to the mandatory use of sanitizers and a greater frequency of cleaning in restaurants and bars. One should note that the Colilert assay used to determine the number of total coliforms in our study also varied from the mEndo plate counts utilized in the household studies *(6, 12)*. Thus, some portion of this discrepancy could be due to the use of different methods.

The total numbers of bacteria, coliforms and *E. coli* (vs. fecal coliforms) found on restaurant tabletops were also lower (2-, 9- and 12-fold, respectively) than those found on household kitchen countertops *(12)*. This was, again, possibly due to the required use of detergents/sanitizers in restaurants. Total bacteria found on tabletops after cleaning was 45-fold greater than before cleaning, perhaps implicating the dishcloths in tabletop contamination. This was most likely due to the inadequate sanitization of the linens used to wipe down tables.

Listeria monocytogenes was not found in any of the dishcloth samples; however, *Listeria inocua* was present in 24.3% of the dishcloths tested. The presence of another *Listeria* species could indicate that conditions may allow for contamination by and persistence of the pathogen *L. monocytogenes*.

Although many of the bacterial isolates identified were similar for both restaurants/bars and homes, *Pseudomonas* spp., and *Klebsiella* spp. were more prevalent in restaurants and bars whereas *Salmonella* spp., *Staphylococcus aureus* and *Aeromonas hydrophila* were more prevalent in homes (Table 2). *Salmonella* spp., which may be isolated from raw chicken and eggs, although commonly found in dishcloths used in household kitchens where raw foods are handled, are not likely to be found in dishcloths used to wipe down tabletops in restaurants and bars, where cooked foods are generally the only foods present. However, the other species differences noted suggest a possible species shift between the microbial populations, because presumably the original microbial popula-

tions should be similar in both environments. This is also possibly due to the mandatory and regular use of sanitizers in restaurants and bars.

Although this study was fairly small, it raises several interesting questions. For instance, although the bacterial numbers found in food service establishments were lower than the numbers found in homes, considerable numbers of coliforms and *E. coli* were still present. This could represent a danger to the public, especially for populations at risk, including the very young, the elderly and the immunocompromised. Also, because the bacterial numbers found on tabletops after wiping with a cloth were higher than the numbers prior to cleaning, the use of such cloths in restaurants and bars could contribute to contamination of surfaces and to the spread of potentially harmful bacteria. Therefore, more careful monitoring of linen sanitization solutions used by food service establishments such as restaurants and bars may be called for.

ACKNOWLEDGMENTS

The authors thank the Departamento de Investigación y Posgrado en Alimentos at the Universidad de Sonora in Hermosillo, Senora, Mexico for their scholarship support of M. Susana Yepiz-Gomez.

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