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Assessment of the Potential for Cross-contamination of Food Products by Reusable Shopping Bags

DAVID L. WILLIAMS,[1] CHARLES P. GERBA,[1]* SHERRI MAXWELL[1] and RYAN G. SINCLAIR[2]

[1]Dept. of Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ 85721, USA;
and [2]Loma Linda University School of Public Health, Dept. of Environmental Health, Loma Linda, CA 92354, USA

ABSTRACT

The purpose of this study was to assess the potential for cross-contamination of food products by reusable bags used to carry groceries. Reusable bags were collected at random from consumers as they entered grocery stores in California and Arizona. In interviews, it was found that reusable bags are seldom if ever washed and often used for multiple purposes. Large numbers of bacteria were found in almost all bags and coliform bacteria in half. *Escherichia coli* were identified in 8% of the bags, as well as a wide range of enteric bacteria, including several opportunistic pathogens. When meat juices were added to bags and stored in the trunks of cars for two hours, the number of bacteria increased 10-fold, indicating the potential for bacterial growth in the bags. Hand or machine washing was found to reduce the bacteria in bags by > 99.9%. These results indicate that reusable bags, if not properly washed on a regular basis, can play a role in the cross-contamination of foods. It is recommended that the public be educated about the proper care of reusable bags by means of printed instructions on the bags or through public service announcements.

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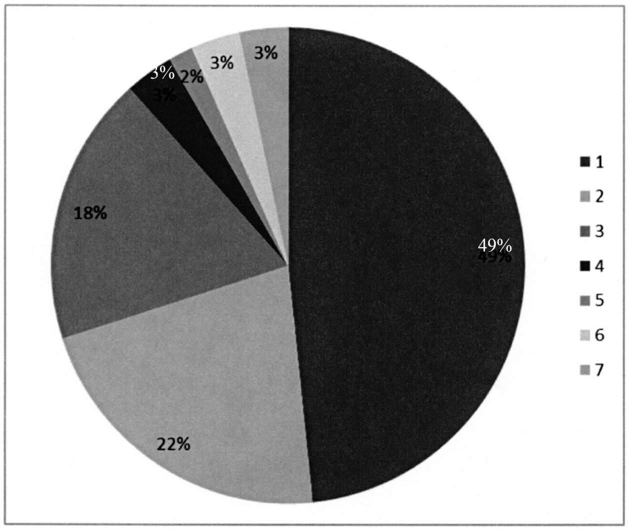
*Author for correspondence: Phone: +1 520.621.6906; Fax: +1 520.621.6366
E-mail: gerba@ag.arizona.edu

INTRODUCTION

Most foodborne illnesses are believed to originate in food prepared or consumed in the home *(1, 2, 10)*. Cross-contamination of foods during handling is one of the factors leading to this assumption. Cross-contamination occurs when disease-causing microorganisms are transferred from one food to another. For example, raw meat products are often contaminated with foodborne bacteria such as *Salmonella* and *Campylobacter (3)*, and, although cooking foods usually destroy these bacteria, the organisms may be transferred to other foods that are sometimes consumed uncooked, or may contaminate the hands of consumers and be directly transferred to the mouth, resulting in infection. Transfer may occur by surfaces such as cutting boards and kitchen counter tops as well as by the hands *(1, 9)*. Reusable bags for transport of groceries from the store to the consumer's home have become popular in recent years. Since these bags are often reused, and potentially are used for multiple purposes, the possibility for contamination of food products as well as the consumer's hands exists *(6)*. The goal of this project was to assess the potential for reusable bags to cross contaminate foods carried in reusable bags.

FIGURE 1. Days used in a week. Interviews indicated that more than half of individuals used their reusable shopping bags more than one day per week.



MATERIALS AND METHODS

Collection and sampling of bags

Shopping bags were collected at random from consumers entering grocery stores in the San Francisco Bay area, greater Los Angeles and Tucson, Arizona. Twenty-eight to 30 bags were collected from each location. Individuals were interviewed on bag usage, storage and cleaning procedures. In addition, five new unused bags purchased at local markets and four new plastic disposable bags were tested. Bags were sampled using sponge-sticks (3M Corporation, St. Paul, MN) by swabbing the entire inside of the bag. Approximately three ml of fluid was extracted from the sponge-stick by squeezing it from the sponge in a plastic bag.

Bacterial assays and identifications

Total heterotrophic plate counts (HPC) bacteria were determined by dilution of samples in buffered peptone water and spread plating on R2A media (Difco, Sparks, MD), a medium designed to enhance the recovery of stressed bacteria. The plates were incubated for five days at room temperature, after which colonies were counted. Coliform and *Escherichia coli* bacteria were identified by placing one ml of the sponge stick extract into 99 ml of Colilert media (IDDEX, Westbrook, ME), which was then placed in a quanti-tray system and incubated overnight at 37°C. Coliform and *E. coli* numbers were then determined using a most probable number (MPN) table provided by the manufacturer. Identification was conducted by diluting positive quanti-tray samples on MacConkey's agar (Difco) to confirm the presence of coliform bacteria, since the Colilert mediium is not specifically designed for isolation of coliform bacteria from fomites. Colonies of different morphology were selected and subcultured on trypticase soy agar (Difco). The bacteria were then identified using APIE20 strips (bioMérieux, Durham, NC). *Salmonella* isolation was attempted by inoculation of one ml of sponge-stick extract into 9 ml of buffered peptone water and incubation for 24 h at 35°C, followed by subculturing in Rappaport-Vassiliadis media (Difco) and incubation at 35°C for 24–48 h. Positive samples (samples containing growth) were then subcultured on both Hektoen enteric and XLD agars (Difco) at 35°C for 24–48 h. *Listeria* isolation was attempted by inoculation of one ml of sponge sickle extract into 9 ml of UVM media (Difco) and incubated at 30°C for 24–48 h followed by transfer into Frasier's broth (Difco), incubation at 35°C for 24–48 h, and then streaking onto RAPID'L mono agar (Bio-Rad, Chicago, IL) for isolation of *Listeria*.

Assessment of bacterial growth in stored bags

To assess the potential for bacterial growth in stored reusable bags, raw chicken and beef were hand wiped with sterile gloves and the resulting juices collected in a beaker. The solution was then spiked with approximately 10^6 *Salmonella* Typhimurium from an overnight culture. The spiked solutin was then added to 8×7 cm swatches cut from reusable grocery bags and placed wet into a zip-closure plastic bag. Half of the swatches were processed immediately by being cut into one cm^2, pieces, placement in 10 ml of buffered peptone water, transfer to a stomacher bag, and processing for 15 minutes in a stomacher. The sample was then diluted and assayed on XLD and R2A media. The other set of samples was placed in the trunk of an automobile for two hours during mid afternoon. The experiment was repeated twice. The temperature inside the bag when it was removed from the trunk was measured with a mercury thermometer. To determine the potential for growth of bacteria in the meat juices, another set of swatches was processed, but without addition of *Salmonella*. This experiment was repeated twice on two different days.

Effect of washing on reduction of bacteria in reusable bags

This phase of the study was designed to assess proper washing conditions to eliminate bacteria from reusable shopping bags. Reusable washable cloth bags were purchased at a local grocery store and spiked with *S.* Typhimurium suspended in meat juices as described in the previous section. The bottom of the bag and the sides were spiked by adding 5 ml in 0.1 ml drops. The bags were then allowed to air dry for 30 minutes. One bag was processed immediately after drying by swabbing with a sponge stick and processed as previously described. The sponge extract was assayed directly on XLD media at 37°C for 24 h and black colonies were counted. An additional three bags were washed with a 30-min wash cycle with a standard household detergent (61.1 g) without bleach (Tide, Procter and Gamble, Cincinnati, OH) in cold water (70°C). The bags were placed

FIGURE 2. Separate bags for meats and vegetables. Seventy-five percent of individuals questioned do not use separate bags for meats and vegetables.

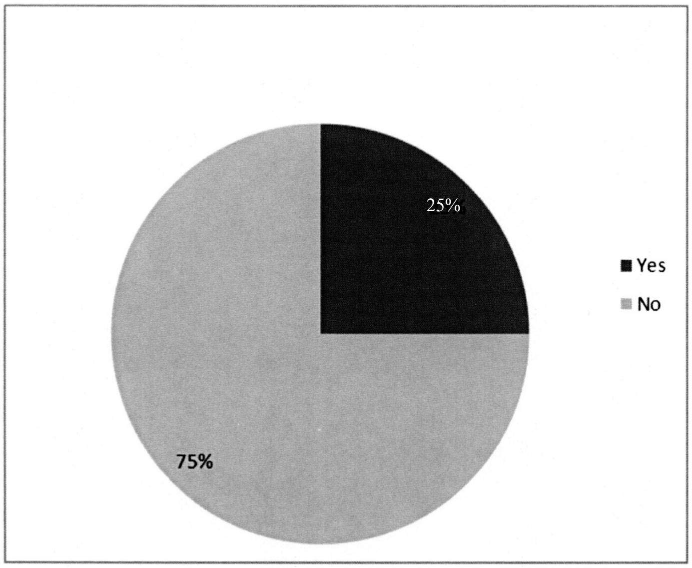
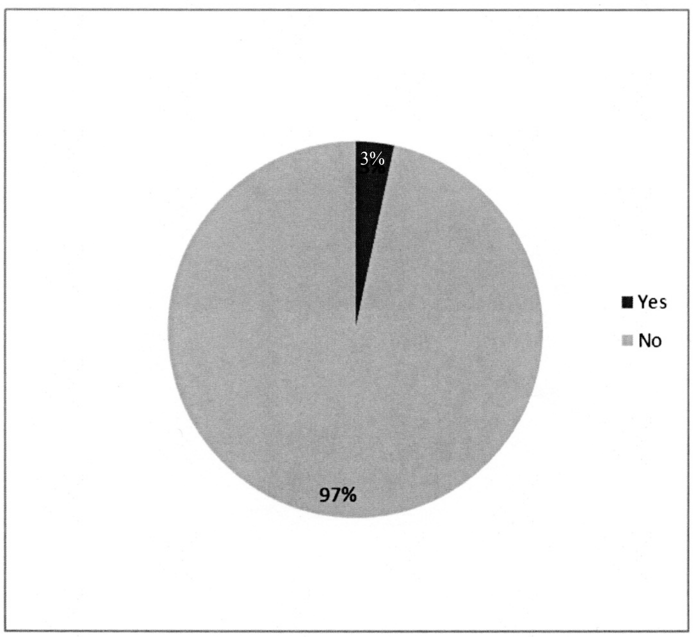


FIGURE 3. Cleaned on a regular basis? Ninety-seven percent of individuals interviewed admitted that they never wash their reusable bags.



in a dryer at 55°C for 20 min and then sampled using a sponge stick and assayed as previously described. Another set of bags was treated in the same manner but with use of a detergent containing bleach (Tide, Procter and Gamble, Cincinnati, OH).

To assess the effect of hand washing, another set of bags was treated in the same manner and were hand washed and rinsed in an 18.9 L bucket containing water, with use of rubber gloves, and allowed to dry overnight before sampling. The bags were placed in the wash water containing detergent (Tide, Procter and Gamble, Cincinnati) (11.3 g in 10 L) and allowed to soak for 30 min before hand washing. The experiment was repeated in duplicate. The effect of adding bleach was examined, as already described.

RESULTS

Profile of bag use

Interviews indicated that half the bags were used more than one day per week (Fig. 1) and that 75% of consumers neglected to separate meats and vegetables (Fig. 2) and only 3% regularly clean their bags (Fig. 3).

Bacteria detected in bags

No bacteria were detected in new cloth reusable bags or in new plastic bags obtained from grocery stores (data not shown). However, large numbers of bacteria were detected in reusable bags collected from consumers. HPC bacteria ranged from 45 to more than 800,000 per bag. Only one bag was negative for HPC bacteria (< 30 CFU). Coliform bacteria were detected in 51% of the bags tested. In bags containing coliform bacteria, the numbers detected ranged from 3 to 3,330 per bag. HPC bacteria averaged 22,600 and coliform bacteria 576. Greater numbers of bacteria and coliform bacteria were found in reusable bags collected in California than in Arizona (Fig. 4). This may be due to the drier climate in Arizona, which could affect bacterial survival. The greatest numbers of HPC and coliform bacteria were found in bags from the Los Angeles area.

A wide variety of coliform bacteria were detected in the bags, including *Escherichia coli*, which was identified in seven bags (8% of bags tested). One positive bag was from Tucson, AZ, and the other positives were from the Los Angeles area (Table 1). Many of the bacteria isolated are capable of causing opportunistic infections in humans. No *Salmonella* or *Listeria monocytogenes* were detected in any of the bags.

Assessment of bacterial growth in stored bags

Bacteria in bags to which meat juices had been added did grow within two hours of storage. Within this time, the number of bacteria increased 10-fold when the temperature was 47°C inside the trunk (Table 2). When this was repeated, the temperature was 53°C, and there was a decrease in the number of

TABLE 1. Identity of coliform bacteria detected in reusable bags

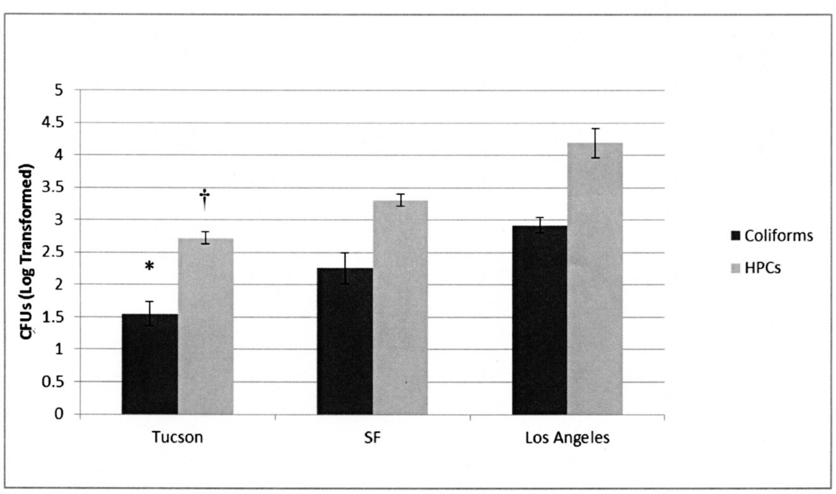
Type of coliform	Number of bags in which deteted
Leclercia adecarboxylata	1
Enterobacter aerogenes	1
Enterobacter cloacae	2
Enterobacter sakazakii	1
Escherichia vulneris	4
Escherichia coli	7
Klebsiella pneumoniae ssp. *pneumoniae*	6
Pantoea spp.	4
Serratia ficaria	8
Serratia (ruidae or plymuthica)	1

TABLE 2. Effect of car trunk storage on the growth of bacteria in reusable bags (HPC)

Trial	Trunk temperature (°C)	Log CFU	
		Before	After
1	47	7.11 +/- 0.026	8.19* +/- 0.105
2	53	7.17 +/- 0.025	6.25* +/- 0.088

*$P < 0.001$

FIGURE 4. Average coliform and HPC bacteria detected in reusable bags by collection location. Greater numbers of bacteria and coliform bacteria were found in reusable bags collected in California than Arizona, most likely attributable to a difference in climate. One-way Anova with Tukey Posthoc. $P < 0.05$.



viable bacteria. Warm temperatures and the presence of food in the bags can encourage rapid growth of bacteria.

Effect of washing on reduction of bacteria in reusable bags

Machine or hand washing, even without bleach, was effective in reducing coliform and other bacteria in the bags to levels below detection (Tables 3 and 4).

DISCUSSION

An estimated 76,000,000 cases of foodborne illness occur in the United States every year *(2)*. Most of these illnesses are believed to originate in the home as the result of improper cooking or handling of foods *(2, 10)*. Reusable bags, if not properly washed between uses, create the potential for cross-contamination of foods, especially when raw

TABLE 3. Effect of washing on bacterial reduction in reusable cloth bags: without bleach

Wash method	Microbial counts before washing* (Log CFU)		Microbial counts after washing* (Log CFU)	
	HPC	*Salmonella*	HPC	*Salmonella*
Machine	5.33	5.89	< 1.48**	<1.48**
Hand	5.48	5.47	< 1.48**	<1.48**

*$P < 0.001$

TABLE 4. Effect of washing on bacterial reduction in reusable cloth bags: with bleach

Wash method	Microbial counts before washing* (Log CFU)		Microbial counts after washing* (Log CFU)	
	HPC	*Salmonella*	HPC	*Salmonella*
Machine	4.95	4.66	< 1.48*	<1.48*
Hand	4.58	4.79	< 1.48*	<1.48*

*$P < 0.001$

meat products and foods traditionally eaten uncooked (fruits and vegetables) are carried in the same bags, either together or in different uses. This risk can be increased by the growth of bacteria in the bags. The results of this study indicate that large numbers of bacteria can be present in reusable bags and are capable of increasing 10-fold in a trunk within a two-hour period. Slightly more than half of the bags contained coliform bacteria, indicating contamination by raw meats or other uncooked food products. *E. coli*, used to indicate fecal contamination, was detected in 8% of the bags. The presence of these bacteria demonstrates that reusable bags do get contaminated by enteric organisms and a risk from foodborne pathogens does exist. Attempts to isolate *Salmonella* and *Listeria* bacteria from the bags were not successful in this study, but this may represent only the limited number of samples collected.

Greater numbers of bacteria were present in bags in California than in Arizona. A similar study in Canada also found fewer total bacteria and coliform bacteria in reusable bags *(6)* than were found in this study. The lower numbers of bacteria found in bags in the Canadian study may represent some differences in methods, or the warmer temperatures in California and Arizona may encourage growth of bacteria in the bags. The greater numbers of bacteria in the bags in California vs. Arizona may reflect the higher relative humidity in California.

Contamination of raw meat products with *Salmonella*, *Campylobacter* and *E. coli* occurs on a regular basis *(3)*. Studies have shown that children are at increased risk of both *Salmonella* and *Camplyobacter* infections if they ride in a shopping cart carrying meat products and if they eat fruits and vegetables prepared in the home *(4, 7)*. This suggests that improper handling of raw food products during shopping and transport to the home is a route of exposure for the transmission of these pathogens. Packaged meats can leak during transport, contaminating the bag. In addition, pathogenic bacteria can also occur on the outside of packaged meats *(5)*. The common use of bags for purposes other than carrying groceries is also a potential concern. Transporting gym clothes or other clothing may result in cross-contamination of bacteria such as MRSA (methicillin-resistant *Staphylococcus aureus*).

Cross-contamination problems associated with reusable bags for carrying groceries has been recognized by health departments *(6, 8)* which have made recommendations about proper handling and cleaning. In this study, it was demonstrated that hand and machine washing were able to reduce the bacteria in the bags below the levels of detection. Unfortunately, almost no one interviewed ever washed their reusable bags. Public unawareness of the potential risks seems almost universal. Approaches such as printed instructions on reusable bags for cleaning between uses or warnings about the need to separate raw foods from other food products, public service announcements, and health advisories are recommended. With increased use of reusable grocery bags, more research is needed to elucidate the bacterial profiles of bags in certain areas and to further identify the risk of transmission of some of these potential pathogens.

CONCLUSIONS AND RECOMMENDATIONS

- Consumers almost never wash reusable bags.

- Bacteria were found in 99% of reusable bags tested, but none in new bags or plastic bags.
- Coliform bacteria were found in 51% of the bags tested, with generic *E. coli* in 8%.
- Bacteria were capable of growth when stored in the trunks of cars.
- A potential risk of bacterial cross-contamination is associated with use of reusable bags to carry groceries.
- Hand or machine washing reduced the numbers of bacteria in reusable bags by > 99.9%.
- Instructions should be printed on reusable bags, indicating that they should be washed between uses and that foods that are usually consumed raw should be separated from other food products.

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