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Comparison of cleaning fabrics for bacterial removal from food-contact surfaces

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ABSTRACT

Food-contact surfaces are highly contaminated with microorganism and great sources for transmission of foodborne pathogens. It is important to eliminate bacteria using appropriate sanitizing approaches to minimize cross-contamination during food preparation and/or consumption and reduce the risk of foodborne diseases. The objective of this study was to compare the removal efficiency of bacteria on food-contact surfaces by different cleaning cloths. Commercially available blended cellulose/cotton cloth, microfiber, scouring cloth, nonwoven fabric and terry towel were used. Stainless steel and Formica laminate surfaces were inoculated with *Listeria monocytogenes* in ready-to-eat turkey slurry and the surface was wiped with different cloths. The remaining bacteria on the food-contact surfaces and bacteria immersed in each cloth were enumerated. Overall significant reductions were observed on stainless steel and Formica laminate surfaces by 0.92–2.62 and 2.21–3.44 log CFU/cm^2 reduction, respectively ($P < 0.05$). Among all cloths, blended cellulose/cotton cloths showed the highest removal efficiency by 2.53–2.62 (stainless steel) and 3.16–3.44 (Formica) log CFU/cm^2 reduction. Bacteria captured by each cloth did not show significant differences with the range of 5.40–5.69 log CFU/cm^2 (stainless steel) and 2.78–3.62 log CFU/cm^2 (Formica). ATP bioluminescence assay result was significantly reduced by cleaning cloths ($P < 0.05$) while the relative luminescence unit (RLU) value was higher on stainless steel by 2547–6073 RLU than on Formica by 208–503 RLU. These results indicate that the performance of cleaning cloths varied for the removal of bacteria and food debris depending on the fabric material and processing pattern.

1. Introduction

Cleaning and sanitizing procedures are essential to maintain the hygiene of food processing environment from bacterial contamination and persistence. With any insufficient decontamination process on the equipment and personal hygiene during food preparation, it can contribute cross-contamination and transmission of foodborne pathogens and increase the risk of outbreaks (Nyachuba, 2010). Outbreaks were frequently associated with restaurants, followed by catered functions, or at special events where the food was prepared at home or on cruise ships, airplanes and trains (Todd, Greig, Bartleson, & Michaels, 2007). In those facilities, food workers may not be the sole contribution of outbreaks but their poor handling can highly influence the cross-contamination (Todd et al., 2007). Pathogens that are attached to food-contact surfaces can easily transfer to food and cause infectious diseases (Todd, Greig, Bartleson, & Michaels, 2009). The presence of food residue due to the poor cleaning practices can even facilitate the attachment and survival of microorganisms (Leon & Albrecht, 2007). Therefore, frequent cleaning on a regular basis is required to remove and prevent any absorbed organic material (food, soil and environment), inorganic material (residue of cleaning agent) and microorganisms (Whitehead, Smith, & Verran, 2008). With failure of removing chemical and biological residue, this will create conditioning films for the initial step of biofilm formation, facilitate cell attachment and eventually become hard to remove (Verran & Jones, 2000). Cleaning refers to the mechanical removal of dirt soil and microorganisms from an object area (Kusumaningrum et al., 2003) and sanitizing refers to the reduction of microbial contamination to the acceptance level for a safe public health on inanimate surfaces (Marriott & Gravani, 2006). A perfect combination of cleaning and sanitizing by selection of appropriate cleaning materials with effective

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detergent–disinfectants is needed to assure the food safety. There have been several studies related to sanitizing agents on various foodborne pathogens; examples are quaternary ammonium compounds, silver dihydrogen citrate, or sodium hypochlorite based sanitizer to inactivate *Staphylococcus aureus*, *Escherichia coli*, and *Listeria monocytogenes* (Lalla & Dingle, 2004; Somers & Wong, 2004; Tebbutt, 1984; Yang, Kendall, Medeiros, & Sofos, 2009). However, limited studies were conducted on the cleaning efficiency of different cleaning cloths against foodborne pathogens. During the decontamination process, cleaning cloths play an important role to initially remove microorganisms including foodborne pathogens from contaminated surfaces (Diab-Elschahawi et al., 2010).

ATP bioluminescence assay is a widely accepted method in the food industry to monitor the hygienic status by detecting microbial contamination and food residues (Davidson, Griffith, Peters, & Fielding, 1999). ATP levels in viable cells are used as an indicator by their reaction with luciferin and luciferase enzyme complex to generate light. The emitted light is measured by a luminometer and the biomass of cells is expressed in relative luminescence units (RLU) (Chen & Godwin, 2006). The result can be detected in a few minutes to provide a real time estimate (Larson et al., 2003). In addition, this assay can not only detect microorganisms but also food residues which is more beneficial since any residue or organic matters indicate the effectiveness of cleaning and hygienic procedures and presence of microorganisms indicates potential impact on public health. However, because ATP bioluminescence detects ATPs of both bacteria and food residues, the assay does not support a consistent correlation between ATP results and bacterial contamination (Aycicek, Oguz, & Karci, 2006).

L. monocytogenes is one of the most severe foodborne pathogens with the highest hospitalization rate of 94% and a high mortality rate of 15.9% (Scallan et al., 2011). The major source of contamination is ready-to-eat (RTE) products and especially RTE deli meat is responsible for about 90% of listeriosis cases in the United States (FDA/USDA, 2003). Contamination of RTE products can be highly dangerous since RTE products are consumed without further cooking process and the contamination occurs during the post-processing steps. *L. monocytogenes* is known to be a biofilm forming organism which can persist in the food processing environment for extended time periods on food-contact surfaces (Renier, Hebraud, & Desvaux, 2011). *L. monocytogenes* isolated from a multistate outbreak by delicatessen turkey meat in 2000 was identified from a processing plant where the same strain has been persisting for over a decade (Olsen et al., 2005). Studies have shown that *L. monocytogenes* attached to the surfaces is more resistant to disinfectants than planktonic cells and the resistance can also be highly affected by the food matrix (Gram, Bagge-Ravn, Ng, Gymoese, & Vogel, 2007; Norwood & Gilmour, 2000; Sinde & Carballo, 2000). Therefore, keeping the food-contact surfaces clean before the pathogen attaches and forms biofilm is important to reduce the risk of cross-contamination in the food processing environment. The aim of this study was to investigate whether cloth material can influence the removal efficiency of *L. monocytogenes* with RTE meat product on different food-contact surfaces.

2. Materials and methods

2.1. Bacteria

Five strains of *L. monocytogenes*; F4243 (4b), ATCC 19112 (1/2c), J2818 (1/2a), J0161 (1/2a) and F6900 (1/2a), previously isolated from humans and food-associated outbreaks were used in this study (Table 1). These strains were grown in tryptic soy broth with 0.6% yeast extract (TSBYE) (Becton Dickinson Co., Sparks, MD) at 37 °C for 18–20 h. A cocktail was prepared by mixing same amount [approx. 9 log colony forming unit (CFU)/ml by plate count] of aliquots of each culture. To simulate real-world deli conditions and provide organic matter in a uniform manner, slurry of turkey luncheon meat, which was purchased from a local grocery store, was blended and mixed with equal aliquots of the cocktail *L. monocytogenes* with final concentration of 8.5 log CFU/ml.

Table 1
Bacterial strains used in this study.

Bacteria	Strain	Serotype	Source	Reference
Listeria monocytogenes	F4243	4b	Philadelphia outbreak in 1987	Schwartz et al., 1989
Listeria monocytogenes	ATCC 19112	1/2c	Spinal fluid of man, Scotland	
Listeria monocytogenes	J2818	1/2a	Sliced turkey from outbreak in 2000	Olsen et al., 2005
Listeria monocytogenes	J0161	1/2a	Human illness case from outbreak in 2000	Olsen et al., 2005
Listeria monocytogenes	F6900	1/2a	Persistent strain found in 1989 and 2000	Olsen et al., 2005

2.2. Preparing food-contact surfaces and cleaning cloths

Standard counter top, Formica laminate surfaces were cleaned with quaternary disinfectant/sanitizer, rinsed, sanitized with cleaners used in the deli industry and kept under UV light for overnight to sterilize the surface. Stainless steel surfaces were also cleaned as Formica laminate and autoclaved to sterilize the surface. Gridded areas 5.5 × 5.5 cm were drawn on the surface. Four different types of cleaning cloths, two blended cellulose/cotton cloths with different thickness 0.18 cm for cellulose/cotton cloth 1and 0.23 cm for cellulose/cotton cloth 2 (cellulose 70%, cotton 30%, Kalle USA, Gurnee, IL), microfiber (polyester 70%, polyamide 30%, Super Detail, Inc. San Diego, CA), nonwoven wipes (viscose 50%, polyester 50%, Ecolab, St. Paul, MN), scouring pad (3M, St. Paul, MN) and cotton terry bar towel (cotton 100%, Mainstays, Pakistan), were purchased for this study. Cloths were cut in 6.35 × 6.35 cm squares, hydrated in sterile deionized water, placed in sterilization pouches (Propper Manufacturing Co., Long Island City, N.Y.), and autoclaved.

2.3. Cleaning cloth evaluation on food-contact surfaces

A 0.5 mL of *L. monocytogenes* cocktail/slurry was evenly spread within each test grid. Positive controls were inoculated areas which were not wiped by test cloths. Negative controls were prepared with turkey slurry only and the surface was not wiped by cloths. All surfaces were allowed to dry for 2 h under biosafety cabinet before sampling. After drying, the inoculated surfaces were wiped with blended cellulose/cotton cloth, microfiber, nonwoven, scouring pad and terry towel, vertically (10x) and horizontally (10x). Cloths were wiped with hands by wearing powder-free latex gloves aseptically (VWR International LLC, Randor, PA) and the gloves were replaced with new gloves for each cloth. Each wiped cloth was collected and mixed with 0.1% peptone water to measure the bacteria transferred into the cloth. Subsequent dilutions were done on these cloths and plated on Modified Oxford (MOX) agar. After cleaning, each test grid was swabbed with sterile calcium alginate applicators (Puritan Medical Products Company, Guilford, Maine), vertically (13x) and horizontally (13x). The applicators were then placed in 0.1% peptone water, vortexed, diluted, and plated on MOX. Plates were incubated at 37 °C for 48 h and enumerated. The data was converted to colony forming units (CFU) per cm^2.