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Clostridium difficile in Retail Meat Products, USA, 2007

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The incidence and severity of *Clostridium difficile* infections (CDIs) are increasing in North America (1), probably because of emergence of an epidemic strain (NAP1/BI/027, toxinotype [TT] III) (2,3). *C. difficile* transmission occurs primarily in healthcare facilities, but community-associated CDI (CA-CDI) appears to be increasing and may now account for 20%–45% of positive diagnostic assay results (4,5). Up to 35% of patients with CA-CDI report no antimicrobial agent use within 3 months before disease onset (4,5), although nonantimicrobial drugs (e.g., proton pump inhibitors, nonsteroidal antiinflammatory agents) are also implicated as risk factors (4). Sources of *C. difficile* acquisition in community settings are unknown.

CDI is increasingly important in food animals (6). Infection rates of >95% have been documented among neonatal pigs in farrowing facilities, resulting in diarrhea and typhlocolitis (6). Toxigenic *C. difficile* is also implicated as a cause of diarrhea in calves (7). *C. difficile* was identified in raw meat intended for pet consumption (8) and in ≥20% of retail ground beef in Canada (9). We report the isolation of *C. difficile* from uncooked and ready-to-eat meats in retail markets in a US metropolitan area.

**The Study**

Packaged meats were purchased from 3 national-chain grocery stores in the Tucson, Arizona, area on 3 occasions at 1-month intervals from January to April 2007. Products sampled were both uncooked (ground beef, ground pork, ground turkey, pork sausage, and pork chorizo) and ready to eat (beef summer sausage, pork braunschweiger) (Table). Pork chorizo was produced and distributed locally; all other samples were national brands. Products with different sell-by dates (a surrogate for production date) were sampled for each meat type. Samples were not representative of all meat products in each grocery store.

For each sample, 1 g of meat was added to two 10-mL tubes of prerduced brain heart infusion (BD, Franklin Lakes, NJ, USA), which had been supplemented with 0.5% yeast extract (BD), 0.05% DL-cysteine (Sigma-Aldrich, St. Louis, MO, USA), and 0.1% taurocholate (MP Biomedicals, Solon, OH, USA). One tube was heat shocked (80°C, 10 min), and both were then incubated anaerobically at 37°C for 72 h. Aliquots were subcultured onto taurocholate cycloserine cefoxitin fructose agar (TCCFA) (10) and incubated anaerobically for 24–72 h at 37°C. Colonies were subcultured onto anaerobic blood agar, TCCFA (with or without antimicrobial agents), and confirmed as *C. difficile* by p-cresol odor, yellow-green fluorescence under UV illumination, a positive L-proline aminopeptidase reaction, and negative indole reaction.

Isolates were characterized by PCR ribotyping (11), toxinotyping (3), and pulsed-field gel electrophoresis (PFGE) (12). Presence of tcdA, tcdB, cdtB (binary toxin), and deletions in tcdC was determined by PCR (2).

MICs were determined by Etest (AB Biodisk, Solna, Sweden) on *Brucella* blood agar with vitamin K and hemin (Remel, Lenexa, KS, USA) that was incubated anaerobically at 35°C. Reference interpretive criteria for *C. difficile* susceptibility to clindamycin and moxifloxacin were used; MICs for levofloxacin and gatifloxacin were interpreted by using criteria for moxifloxacin (13). *Bacteroides fragilis* ATCC 25285, *B. thetaiotaomicron* ATCC 29741, *C. difficile* ATCC 700057, and *Enterococcus faecalis* ATCC 29212 were included as controls.

Proportions were compared by χ² or Fisher exact test. Thirty-seven (42.0%) of 88 retail meats yielded *C. difficile*, including 42.4% of beef, 41.3% of pork, and 44.4% of turkey products (Table). Ready-to-eat products were more commonly culture positive (11/23; 47.8%) than were uncooked meats (26/65; 40.0%), although the difference was not significant (p = 0.34). The highest percentages of *C. difficile* isolates were recovered from pork braunschweiger (62.5%) and ground beef (50.0%). Culture-positive results came from both heat-shocked and non–heat-shocked cultures, whereas culture-negative specimens were negative in both types of culture, and no specimen was positive by both methods (not shown). No association was found with the meat processor, the sell-by date, the store, or the month sampled (not shown). Multiple independent cultures from 2 braunschweiger samples yielded indistinguishable isolates.
The 078/TT V isolates were uniformly susceptible to levofoxacin, moxifloxacin, and gatifloxacin. Like human TT V isolates (12), most 078/TT V meat isolates were non-susceptible to clindamycin (56% resistant, 41% intermediate). This may not be surprising given the widespread use of tylosin, erythromycin, virginiamycin, and lincomycin in food animals and the potential for selection of macrolide-lincosamide-streptogramin resistance (14).

NAP1 isolates have demonstrated high-level resistance to levofoxacin, moxifloxacin, gatifloxacin (>32 µg/mL), and clindamycin (>256 µg/mL), consistent with current human strains (2). NAP1-related isolates were susceptible to levofoxacin, moxifloxacin, and gatifloxacin but resistant to clindamycin, similar to the pattern of historic NAP1 strains (2).

**Conclusions**

Fluoroquinolones are widely used in human therapy, and the current epidemic strain may have emerged because of its resistance to these agents. Fluoroquinolone use is limited in food animal production (14), with the exception of enrofloxacin for treatment of bovine respiratory disease (now approved for use in swine).

The source of *Clostridium difficile* in retail meats may involve direct or indirect human-to-human transmission is responsible for most healthcare-related CDIs (15) and most likely contributes to CA-CDI. Therefore, stopping such
transmission remains the critical control point for preventing most human CDIs. Nonetheless, our findings highlight the potential both for selection of virulent or resistant strains in animals and interspecies transmission through the food supply. Our data do not prove transmission of *C. difficile* from foods to humans but highlight the need for studies to characterize risks posed by this organism in the human food supply.

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Dr Songer is professor of Veterinary Science and Microbiology at the University of Arizona. His research interests focus on bacterial diseases of food animals, mainly those affecting the gastrointestinal tract.