BACTERIA PATHOGEN CHANGES IN FRESH PORK AFTER STORAGE AND CONSUMER ABUSE

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Background

Mishandling and abuse of fresh meat, which can occur at any point in the food chain (e.g., processing, at supermarkets/restaurants or in the home) may lead to proliferation of meatborne pathogens. Public awareness of food safety issues increased during the last decade (McIlveen et al., 1999), and incidence of food-borne disease continues to increase. Worsfold and Griffith (1997) reported that 40% of consumers subjected food to temperature abuse during transport and storage. Consumer education is a key component of pathogen reduction strategies because a significant number of foodborne illness outbreaks are caused in part by food mishandling practices (Tietjen and Fung, 1995) like inadequate cooking or prolonged cooling or thawing at room temperature. Altekruse et al. (1995) reported that one-third of study respondents reported unsafe food handling practices such as not washing their hands or not taking precautions to prevent cross-contamination from raw meat. Woodburn and Raab (1997) surveyed food preparers and found that only 60% recognized the role of thorough cooking for minimizing foodborne illness risk. Safety and shelflife of meat depend on initial microbial contamination, use of good manufacturing practices, proper packaging and appropriate storage temperature (Podolak et al., 1996; Van Netten et al., 1997). Proper refrigeration, even in vacuum packages, may not prevent growth/survival of pathogens because some are psychrotrophs (Marth, 1998), some are facultative anaerobes and some are microaerophic.

Objectives

This study investigated the responses of *Campylobacter jejuni, Escherichia coli* O157:H7, *Salmonella* spp., *Yersinia enterocolitica* and *Listeria monocytogenes* after cold (0°C) storage under vacuum and subsequent aerobic temperature abuse (16, 21 or 27°C) in inoculated ground pork and pork loin chops.

Methods

Chops (2.5 cm thick) from center-cut loins, made with a slicer (Hobart Mfg. Co., Troy, OH) were cut into 4 cm wide by 8 cm long pieces and placed in sterile plastic bags. Pork trim was ground (3.2 mm plate; Hobart Mfg. Co., Troy, OH grinder) and divided into 100 g portions in individual sterile vacuum bags. The inoculated pathogens included *L. monocytogenes* (four pork variety meat isolates, LCDC 81861 and Scott A), *Salmonella* (group B, *S.* Enteritidis, four pork carcass isolates and two pork variety meat isolates), *Y. enterocolitica* (one pork variety meat isolate and ATCC 51871), *C. jejuni* (five pork variety meat isolates) and *E. coli* O157:H7 (ATCC 43895, 43888, 43889, 43890, 51657, 51658). Each sample was inoculated with 10^3- 10^5 CFU/cm^2 (chops) or CFU/g (ground) of each pathogen. After inoculation, each sample was vacuum (-85 bar) sealed. Samples were stored at 0°C for 18 d (ground pork) or 20 d (pork chops), and then aseptically transferred to styrofoam trays lined with absorbent pads and wrapped with a polyvinyl-chloride film. One set of samples was held for 24 h at 4°C (to simulate retail display) before they were divided equally among 16, 21 or 27°C incubators; the other set was stored immediately. Samples (1-2 per treatment in each of three replicates) were analyzed before storage (0°C), following storage but before temperature abuse, and after 3 and 6 h of temperature abuse. Samples were plated on a general growth medium (TSA), lactic acid bacteria medium (MRS), 3M™ Total Coliform Count Petrifilm™, and selective agar media appropriate for each organism. Plates were then inverted and incubated at 25° (aerobically), 35° (aerobically) or 42°C (microaerophilic environment) depending on the temperature appropriate for the organism. Colonies were counted after 24-48 h and results were expressed as log CFU/cm^2 (chops) or log CFU/g (ground) for calculation of means and standard deviations.

Results and Discussion

At 20 d storage at 0°C, counts (Table 1) on chops inoculated with *C. jejuni* or *L. monocytogenes* declined by 0.8 and 0.7 log, respectively, while chops inoculated with *E. coli* O157:H7, *Salmonella,* or *Y. enterocolitica* showed no substantial changes (0 to 0.4 log). Storage (20 d at 0°C) and temperature/time abuse (3 or 6 h at 16-27°C) with no simulated display did not increase counts by 1.0 log or more in any of the treatment groups for chops inoculated with *C. jejuni, E. coli* O157:H7, *L. monocytogenes* or *Salmonella* and in 5 of 6 treatment groups for chops inoculated with *Y. enterocolitica* (the exception was an increase of 1.3 log for chops held 3 h at 21 h). Storage (20 d at 0°C), temperature/time abuse (3 or 6 h at 16-27°C) and simulated display (24 h at 4°C) did not increase counts by 1.0 log or more in any of the treatment groups for chops inoculated with *C. jejuni, E. coli* O157:H7, *L. monocytogenes* or *Salmonella* and in 4 of 6 treatment groups for chops inoculated with *Y. enterocolitica* (the exceptions were increases of 1.8 and 2.3 log for chops held 3 h at 16°C or 3 h at 27°C, respectively). At 18 d storage at 0°C, counts (Table 2) in ground pork inoculated with *C. jejuni, E. coli* O157:H7, *L monocytogenes* or *Salmonella* declined by 0.5 to 0.9 log while counts in ground pork inoculated with *Y. enterocolitica* had increased by 1.1 log. Storage (18 d at 0°C) and temperature/time abuse (3 or 6 h at 16-27°C) with no simulated display: (a) did not increase counts by 1.0 log or more in any of the treatment groups for chops inoculated with *C. jejuni*, *E. coli* O157:H7 or *L. monocytogenes*; (b) generated decreases in counts of 0.5 to 1.0 log or more in 6 of 6 treatment groups for chops inoculated with *Y. enterocolitica*. Storage (18d at 0°C), temperature/time abuse (3 or 6 h at 16-27°C) and simulated display (24 h at 4°C): (a) decreased counts by 1.0 log or more on chops in 3 of 6 treatment groups for chops inoculated with *C. jejuni* and in 1 of 6 treatment groups for chops inoculated with *Salmonella*; (b) did not increase counts by 1.0 log or more in any of the treatment groups for chops inoculated with *E. coli* O157:H7 or *L. monocytogenes*, and; (c) inoculated with *Y. entercolitica*.

Conclusions

These results verify that temperature abuse may promote proliferation of some meatborne pathogens (particularly *Y. enterocolitica*), and the results should be useful in risk assessment studies. This study also demonstrates the need for minimizing initial

contamination levels of fresh meat and the importance of educating consumers with respect to safe food handling practices.

Table 1. Mean [log CFU/cm^2 (SD)] bacterial counts by plating samples of pork chops inoculated with *Campylobacter jejuni, Escherichia coli* O157:H7, *Listeria monocytogenes, Salmonella* spp., or *Yersinia enterocolitica* and subjected to aerobic temperature abuse (16, 21 or 27°C) for 3 or 6 h following 20 days of vacuum storage at 0°C and display at 4°C for 0 or 24 h.

					Bacterial Counts [log CFU/cm^2 (SD)]				
Storage (days at 0°C)	Simulated display (hours at 4.4°C)	Abusive temperature (°C) and time (h)		N	*C. jejuni* (MCCDA)	*E. coli* O157:H7 (SMAC)	*L monocytogenes* (PALCAM)	*Salmonella* (XLT4)	*Y. nterocolitica* (CIN)
0	-	-	0	6	4.1 (1.8)	5.0 (1.1)	5.1 (0.1)	4.5 (1.2)	4.5 (0.4)
20	0	-	0	3	3.3 (2.1)	5.2 (0.2)	4.4 (0.3)	4.5 (0.4)	4.9 (0.8)
20	0	15.6	3	3	2.2 (2.3)	4.7 (0.3)	4.5 (0.3)	4.7 (0.4)	4.0 (0.3)
20	0	15.6	6	3	4.4 (0.4)	5.4 (0.9)	4.6 (0.6)	4.7 (0.1)	5.0 (1.5)
20	0	21.1	3	3	3.4 (2.2)	4.7 (0.5)	4.2 (0.4)	4.5 (0.3)	5.8 (1.6)
20	0	21.1	6	3	4.5 (0.3)	5.1 (0.6)	4.9 (1.4)	4.7 (0.3)	4.3 (1.0)
20	0	26.6	3	3	3.4 (2.2)	4.8 (0.1)	4.7 (1.2)	4.4 (0.1)	5.3 (1.3)
20	0	26.6	6	3	4.3 (0.3)	5.2 (0.4)	4.4 (1.3)	4.7 (0.6)	5.1 (0.5)
20	24	-	0	3	3.6 (2.4)	4.8 (0.2)	4.1 (0.4)	4.3 (0.2)	4.5 (2.2)
20	24	15.6	3	3	4.4 (0.4)	5.6 (0.8)	5.1 (1.3)	4.7 (0.7)	6.3 (0.6)
20	24	15.6	6	3	4.2 (0.3)	5.0 (0.6)	4.2 (0.2)	3.6 (0.7)	4.6 (0.6)
20	24	21.1	3	3	4.4 (0.3)	4.8 (0.1)	4.7 (1.0)	4.4 (0.2)	4.4 (1.1)
20	24	21.1	6	3	4.3 (0.3)	5.0 (0.5)	5.1 (1.5)	4.3 (0.6)	4.5 (2.0)
20	24	26.6	3	3	4.5 (0.2)	5.1 (0.5)	4.5 (0.8)	4.5 (0.9)	6.8 (1.4)
20	24	26.6	6	3	4.6 (0.4)	5.4 (1.0)	5.1 (1.2)	4.0 (0.4)	4.9 (1.7)

MCCDA = Modified Campylobacter Charcoal Differential Agar, SMAC = Sorbitol MacConkey Agar, XLT4 = Xylose Lysine Tergitol 4 Agar, CIN = Yersinia Selective Agar.

Pertinent Literature

Altekruse, S.F., B.B. Timbo, M.L. Headrick and K.C. Klontz. 1995. J. Behav. Med. 18:225-232.
Marth, E. H. 1998. Food Tech. 52:59-62.
McIlveen, H., C. Abraham and G. Armstrong. 1999. Nutrition and Food Science 1:29-36.
Podolak, R. K., Zayas, J. F., Kastner, C. L. and Fung, D. Y. C. 1996. J Food Prot. 59:1037-1040.
Tietjen, M. and Fung, D. Y. C. 1995. Critical Reviews in Microbiology 21:53-83.
Van Netten, P., A. Valentihn, D.A.A. Mossel and J.H.J. Huis in't Veld. 1998. J. Appl. Microbiol. 84:559-567.
Woodburn, M.J. and C.A. Raab. 1997. J. Food Prot. 60:1105-1109.
Worsfold, D. and C.J. Griffith. 1997. J. Food Prot. 60:399-406.

Table 2. Mean [log CFU/cm^2 (SD)] bacterial counts of ground pork inoculated with *Campylobacter jejuni, Escherichia coli* O157:H7, *Listeria monocytogenes, Salmonella* spp., or *Yersinia enterocolitica* and subjected to aerobic temperature abuse (16, 21 or 27°C) for 3 or 6 h following 20 days of vacuum storage at 0°C and display at 4°C for 0 or 24 h.

					Bacterial Counts [log CFU/cm^2 (SD)]				
Storage (days at 0°C)	Simulated display (hours at 4.4°C)	Abusive temperature (°C) and time (h)		N	*C. jejuni* (MCCDA)	*E. coli* O157:H7 (SMAC)	*L. monocytogenes* (PALCAM)	*Salmonella* (XLT4)	*Y. enterocolitica* (CIN)
0	-	-	0	6	5.1 (0.3)	4.8 (0.5)	4.8 (0.8)	4.6 (0.6)	4.4 (0.6)
18	0	-	0	3	4.5 (0.3)	4.2 (0.4)	4.3 (0.7)	3.7 (0.5)	5.5 (1.1)
18	0	15.6	3	3	4.6 (0.4)	4.6 (1.0)	4.4 (0.8)	3.7 (0.7)	5.3 (1.4)
18	0	15.6	6	3	4.0 (0.9)	4.4 (0.8)	4.6 (1.0)	3.6 (0.5)	5.5 (1.0)
18	0	21.1	3	3	4.6 (0.5)	4.5 (0.9)	4.4 (1.0)	3.9 (0.4)	5.5 (1.0)
18	0	21.1	6	3	3.9 (0.8)	4.5 (0.6)	4.6 (1.0)	3.7 (0.5)	5.7 (1.1)
18	0	26.6	3	3	4.4 (0.3)	4.6 (1.1)	5.0 (1.2)	3.8 (0.6)	5.4 (1.4)
18	0	26.6	6	3	3.9 (1.4)	4.9 (0.9)	4.8 (1.2)	4.1 (0.6)	6.1 (1.1)
18	24	-	0	3	3.1 (1.8)	4.2 (0.5)	4.7 (1.1)	3.8 (0.5)	5.7 (1.1)
18	24	15.6	3	3	4.0 (1.3)	4.9 (0.9)	4.8 (0.4)	3.9 (0.6)	5.8 (0.8)
18	24	15.6	6	3	4.7 (0.5)	4.8 (1.2)	4.7 (0.9)	3.6 (0.6)	5.9 (0.5)
18	24	21.1	3	3	4.5 (0.1)	4.6 (0.8)	4.9 (1.3)	3.8 (0.5)	5.6 (1.0)
18	24	21.1	6	3	4.1 (0.4)	5.4 (1.0)	5.3 (0.7)	3.8 (0.6)	6.3 (0.7)
18	24	26.6	3	3	4.5 (0.6)	5.3 (0.6)	5.1 (0.6)	3.8 (0.4)	5.9 (0.9)
18	24	26.6	6	3	3.7 (0.6)	5.6 (0.8)	5.5 (0.7)	4.3 (0.9)	6.5 (0.5)

MCCDA = Modified Campylobacter Charcoal Differential Agar, SMAC = Sorbitol MacConkey Agar, XLT4 = Xylose Lysine Tergitol 4 Agar, CIN = Yersinia Selective Agar.