Campylobacter survival through poultry processing

Lesley Duffy

Food Safety and Stability
CSIRO Animal, Food & Health Sciences
39 Kessels Road, Coopers Plains
Qld 4053, Australia
Tel: +61 7 3214 2055
Fax: +61 7 3214 2062
Email: Lesley.Duffy@csiro.au

Australia has recorded around 100 cases of campylobacteriosis per 100,000 population, each year, since the mid-1990's. *Campylobacter jejuni* and *C. coli* are recognized as the main species isolated from clinical cases. Approximately 30% of cases have been linked to poultry. Through poultry processing, from slaughter to packaging, the prevalence and concentration of *Campylobacter* can be reduced. Published Australian data on the effect of current processing conditions are minimal. Data from other countries suggests that the stages of scalding and immersion chilling can have significant impact on the prevalence and concentration of *Campylobacter*. Understanding the complexities of these processing stages (physical, chemical and microbiological) and their effect on *Campylobacter* species may lead to improved control during processing and hence improved public health outcomes.

Campylobacter spp. are the leading cause of bacterial gastroenteritis in Australia and most of the western world. While most cases are sporadic in nature rather than outbreak related, poultry has been associated with 30% of all cases in Australia[1]. Poultry are the natural host of this organism with *C. jejuni* and *C. coli* considered the predominant species. Flocks can become contaminated from as early as 14 to 21 days of age[2]. Once *Campylobacter* enters a flock during the rearing period, it spreads rapidly such that flocks can be contaminated at high levels at slaughter, dependent on age[3]. Poultry are slaughtered and prepared for sale through a multistage process (Figure 1). This process can be described in stages: 1. stunning, either electrical or gas; 2. bleeding, severing of the carotid artery and jugular vein; 3. scalding, at temperatures from 53°C to 58°C for approximately two to three minutes to loosen feathers; 4. defeathering, removal of feathers; 5. evisceration, removal of the viscera; 6. washing, both inside and outside of the chicken carcase to remove gross organic contamination; 7. chilling, water immersion from 30 min to 3 h or air chilling from 60 to 80 min, to drop the temperature of the carcase and 8. packaging or further processing. *Campylobacter* can survive each of these processing steps and subsequent storage through to retail and food preparation for poultry to be a source of human infection. Although there is no specific processing step that will kill *Campylobacter* spp., good control of both scalding and chilling can significantly reduce the concentration of *Campylobacter* spp.[4]. Studies have been published in a number of countries that examine the change in prevalence and on the concentration of *Campylobacter* spp. at the various processing stages. A reduction in the concentration of *Campylobacter* spp. by 2 $\log_{10}$ can lead to a reduction in the number of human cases by up to 30 times[5].

A systematic review of the prevalence of *Campylobacter* through poultry processing was published by Guerin[4]. This review of 29 separate published studies covering different stages of the process, highlights the highly variable nature of the effects of various poultry processing stages. Scalding decreased the prevalence of *Campylobacter* anywhere between 20 and 40% while defeathering increased the prevalence between 10 and 72% from four studies. A decrease in prevalence of between 10 and 100% was found after chilling in 6 of the 9 studies which examined this stage, while there was an increase in prevalence after chilling up to 27% in the other three studies. The process of immersion chilling has been demonstrated to lead to cross contamination events which may in part explain an increase in prevalence after chilling. A recent Australian study of four flocks found no decrease in prevalence from pre-scald to pre-chill and reductions in prevalence within two flocks after chill of 10 and 20%[6]. More important than prevalence alone, knowledge on the effect on the concentration of *Campylobacter* at each processing stage is more limited although both scalding and chilling stages are frequently reported to result in a decrease in concentration of *Campylobacter*[4]. Scalding temperature affects the extent of reduction in *Campylobacter* spp. concentration as does the equipment with counter-flow multi stage scalding tanks decreasing the level of contamination. In countries where chlorination of the chilling water is allowed, significant reductions can be made with improved control of chlorine and pH levels within the chilling tanks. The

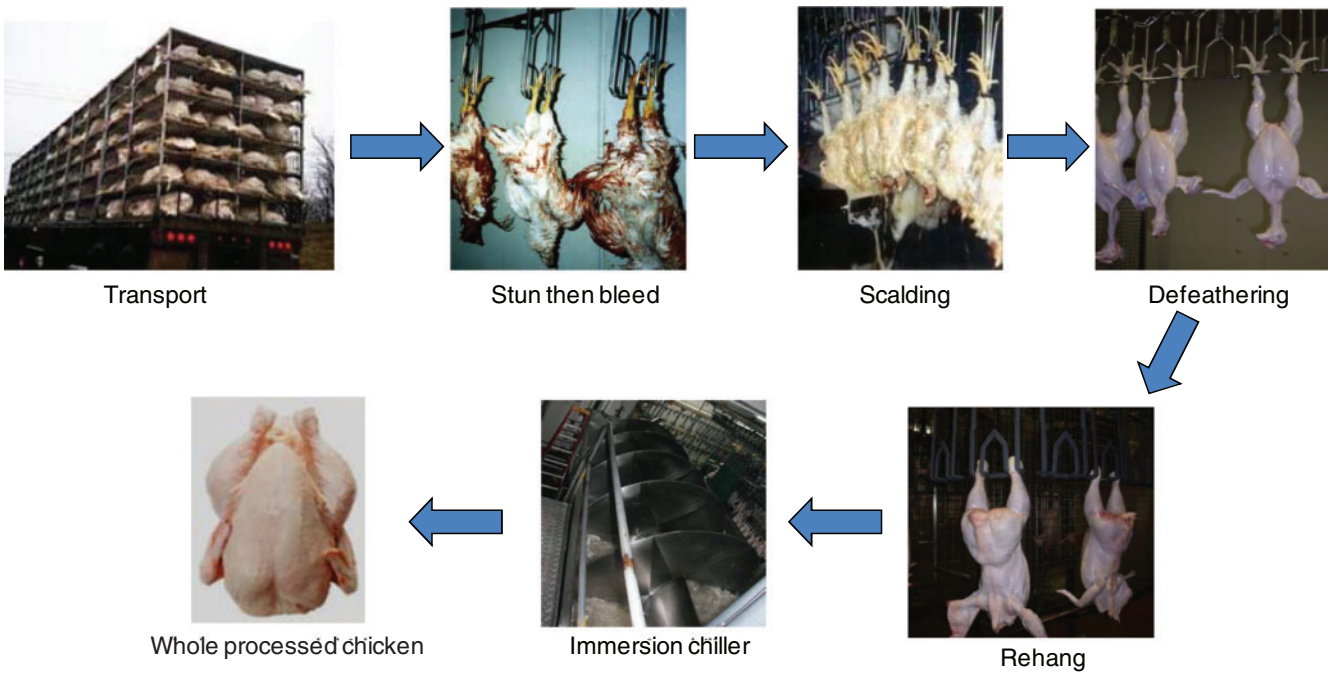

Figure 1. Schematic diagram of poultry processing stages.

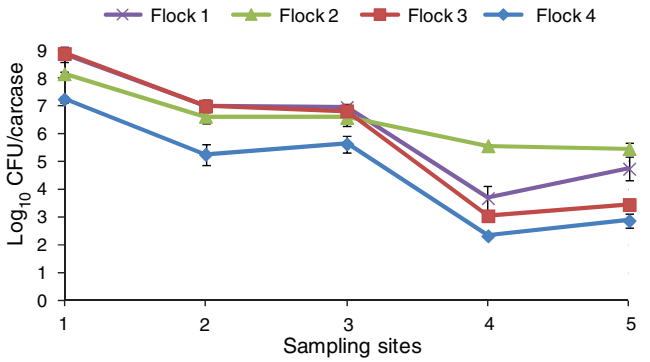

Figure 2. Concentration (log_{10} CFU/carcase) at each sampling site for four flocks. Sampling sites 1. Before scald; 2. After scald; 3. Before chilling; 4. After chilling; 5. After packaging. Flock 1 and 3 were processed at Abattoir A and flock 2 and 4 were processed at abattoir B.

decrease in the concentration of *Campylobacter* within New Zealand processed chickens has in part been attributed to the better control of these parameters in processing[7]. Chlorine dissolves in water to form hypochlorous acid and hypochlorite ion[8]. Hypochlorous acid is the most biocidal form although the formation of these two compounds is pH dependent. The acid form is very reactive being both an oxidizing and halogenating species and therefore the level of free available chlorine in conjunction with pH and contact time will determine the effectiveness of chlorine as a disinfectant on poultry[8].

An Australian study measured the concentration of *Campylobacter* spp. at each stage during processing[6] (Figure 2). Significant reductions were achieved after scalding and again after chilling. No significant changes in concentration were noted after evisceration or after packaging. A few studies have examined the effect of scalding temperatures and chlorine levels under laboratory conditions on the decimal reduction times (D values). A single strain of *Campylobacter* had D_{55C} values in scald tank water of 0.2 min for planktonic grown cells compared with 2.2 min for cells attached to chicken skin. Sub-populations were noted that had increased D_{55C} values of 13.9 min in water and 19.4 min attached to skin. These sub-populations may indicate a level of resistance within the *Campylobacter* population. When the same strain was subjected to chlorine at 50ppm, D_{50ppm} values were recorded of 0.5 min in water compared to 73.0 min when attached to chicken skin with no sub-population detected. New Zealand *Campylobacter* isolates from poultry do not have unusual heat resistance and have similar heat resistance in the planktonic state as those belonging to the sub-populations mentioned above (D_{55C} 8.5 – 17.0 min)[9]. No heat or chlorine resistance data are available on Australian isolates.

The factors that influence the effectiveness of the immersion chiller in the Australian situation where chlorine is a permissible processing aid, are numerous and complex. Examining chickens from two separate flocks, processed at the same abattoir with the same measured pH and chlorine levels in the immersion chiller does not always produce a similar decrease in the concentration of *Campylobacter*[6]. Clearly other aspects of poultry production at the chilling stage, both physical and chemical, can have a significant impact on the survival of *Campylobacter*. Consideration must also be given to the strain to strain variation common in *Campylobacter* studies and the extensive variation in the genetic makeup of this organism compared to other enteric bacteria previously noted by Park[10]. The genotypic variation within the *Campylobacter* genus

may allow specific genotypes to occur or be selected for, when encountering environmental stresses[11].

Understanding the changes that *Campylobacter* spp. undergo when subjected to typical processing temperatures and chilling (chlorine and pH) conditions in conjunction with an understanding of how these are applied within the technical aspects of poultry production, may be key to ensuring future declines in both prevalence and concentration of *Campylobacter* spp. on poultry products. This may lead to improved public health outcomes.

References

1. Stafford, R.J. *et al*. (2008) Population-attributable risk estimates for risk factors associated with *Campylobacter* infection, Australia. *Emerg. Infect. Dis.* **14**, 895–901. doi:10.3201/eid1406.071008
2. Wagenaar, J.A. *et al*. (2008) Poultry colonization with *Campylobacter* and its control at the primary production level. In *Campylobacter* (Third edn) (Nachamkin, I., *et al.*, eds), ASM Press.
3. Berndtson, E. *et al*. (1996) *Campylobacter* incidence on a chicken farm and the spread of *Campylobacter* during the slaughter process. *Int. J. Food Microbiol.* **32**, 35–47. doi:10.1016/0168-1605(96)01102-6
4. Guerin, M.T. *et al*. (2010) The change in prevalence of *Campylobacter* on chicken carcasses during processing: a systematic review. *Poult. Sci.* **89**, 1070–1084. doi:10.3382/ps.2009-00213
5. Rosenquist, H. *et al*. (2003) Quantitative risk assessment of human campylobacteriosis associated with thermophilic *Campylobacter* species in chickens. *Int. J. Food Microbiol.* **83**, 87–103. doi:10.1016/S0168-1605(02)00317-3
6. Duffy, L.L. *et al*. (2011) Survival of *Campylobacter* through the poultry processing chain. In *16th International Workshop on Campylobacter, Helicobacter & Related Organisms*.
7. Sears, A. *et al*. (2011) Marked campylobacteriosis decline after interventions aimed at poultry, New Zealand. *Emerg. Infect. Dis.* **17**, 1007–1015. doi:10.3201/eid1706.101272
8. FAO/WHO (2008) Benefits and risks of the use of chlorine-containing disinfectants in food production and food processing, report of a joint FAO/WHO expert meeting. http://www.fao.org/ag/agn/agns/files/Active%20Chlorine%20Report%20Version%20Final%20December%202009.pdf
9. Sakkaf, A.A. and Jones, G. (2012) Thermal inactivation of *Campylobacter jejuni* in broth. *J. Food Prot.* **75**, 1029–1035. doi:10.4315/0362-028X.JFP-11-518
10. Park, S.F. (2002) The physiology of *Campylobacter* species and its relevance to their role as foodborne pathogens. *Int. J. Food Microbiol.* **74**, 177–188. doi:10.1016/S0168-1605(01)00678-X
11. Wassenaar, T.M. *et al*. (1998) Evidence of genomic instability in *Campylobacter jejuni* isolated from poultry. *Appl. Environ. Microbiol.* **64**, 1816–1821.

Biography

Lesley Duffy is a Research Microbiologist with CSIRO. Her research projects have included the ecology of *E. coli* O157 and *Salmonella* in red meat production systems including beef, sheep and goat; source tracking of *Listeria* in cooked meat and ready-to-eat food production facilities; and the survival of *E. coli* O157 during the manufacture of fermented meat products. Lesley's current research project examines the ecology of *Campylobacter* during poultry processing and the selection and survival of specific genotypes through this process.

Future issues of *Microbiology Australia*

September 2013: Microbes and chronic disease

Guest Editor: Bill Rawlinson

November 2013: Diagnostics into the future

Guest Editors: Theo Sloots, Cheryl Bletchly, Mark Krockenburger

Some of the issues for 2014 and 2015

Microbial diseases and products that shaped the world's history

Guest Editor: Ipek Kurtböke (a joint issue with the Microbiology Society of Turkey)

AIDS

Guest Editors: Johnson Mak and Steven Kent

Coinciding with the international AIDS meeting to be held in Melbourne in July 2014.

Hospital-Acquired Infections, Susceptibility Testing and Infection Control

Guest Editors: Lyn Gilbert, Jon Iredell and John Merlino

Medical Mycology

Guest Editor: Wieland Meyer