Campylobacter update – the solution

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It is important to be able to assess the relative contributions of the various sources and vehicles responsible for human cases involving Campylobacter jejuni and C. coli.

While serotyping, biotyping and bacteriophage typing have been widely used, these methods have limited discriminatory powers and, with available serotyping schemes, many strains cannot be typed at all. The more recent development of genetic typing techniques opens the way for much better strain discrimination, because campylobacters are known to be genotypically diverse.

However, progress in developing and applying the techniques has been slow and choices need to be made in relation to discriminatory power, ease of use, rapidity, cost and reproducibility. Also, there is an inherent genetic instability in the organisms that can complicate the interpretation of sub-typing data in some cases. International agreement on the methods to be used and their application, often in a two tiered approach, is essential for epidemiological purposes across the globe.

Control on the farm

With increasing emphasis on campylobacter colonisation of poultry flocks, attention is being directed at on-farm control. While intensive systems of production are often blamed for encouraging the spread of foodborne pathogens among the large numbers of live birds being reared together, there are advantages from the viewpoint of controlling microbial access to the flock.

Thus, the use of controlled environment housing enables biosecurity measures to be taken that would not be possible otherwise. More recent experience suggests that high standards of biosecurity, including the use of barrier hygiene, are needed if there is to be any real impact on the prevalence of campylobacter colonisation and, equally, biosecurity alone is not sufficient to prevent flocks from becoming colonised.

The most that can be achieved with this approach alone is a delay in colonisation rather than its prevention.

What other control measures are available? Unlike the salmonella situation, there is no vaccine at present for thermophilic campylobacters and, although there are humoral immune responses following infection, these neither clear the colonisation nor prevent infections from subsequent exposure.

This article is the conclusion to the article on the challenge of campylobacter, which appeared in the last issue of International Poultry Production.

It seems likely that any effective vaccine for controlling campylobacter would need to target colonisation factors that are still not fully understood. Strategies aimed at producing high levels of mucosal antibody in the gut may be difficult, because campylobacter is capable of extensive mutation in relation to its lipopolysaccharide, surface antigen coat.

This leads to immune escape unless the immune system is directed at non-mutating surface structures. Another possible approach is the use of bacteriophages that inactivate campylobacters and could be introduced via drinking water as a pre-slaughter decontamination treatment.

However, it is doubtful whether this approach would be fully effective, especially against invasive strains, and there is the possibility of phage resistance developing in the target organism.

Attempts to manipulate the composition of the intestinal microflora in poultry, as a means of controlling pathogen colonisation, have a long history. In relation to salmonella, development of the 'competitive exclusion' concept in Finland in the 1970s led to various commercial preparations that were essentially cultures of intestinal content from specific pathogen free donor birds.

These allowed the establishment of an adult type intestinal microflora in newly hatched chicks to increase host resistance to salmonella colonisation.

Such preparations are widely used in some countries for salmonella control, but appear to be less effective, or even ineffective, under field conditions, against campylobacters. Because the latter organisms occupy a specific niche in the gut, it seems likely that the bacteria needed for host protection are different from those that are effective against salmonella.

Also, it is more difficult to identify suitable donor birds, suggesting that organisms antagonistic to campylobacter are less common in poultry flocks.

Furthermore, treatment materials are

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		Campylobacter numbers Free chlorine conc. (mg/l)		
Strain	**Initial Nos.**	**250**	**50**	**10**
Stainless steel discs				
CS – 21	5.2	< 1.2	< 1.2	< 1.2
CS – 30	4.6	< 1.2	< 1.2	< 1.2
CS – 34	5.4	< 1.2	< 1.2	< 1.2
Chicken skin portions				
CS – 21	6.2	5.4	5.9	6.1
CS – 30	5.3	4.8	5.0	5.1
CS – 34	4.9	4.6	4.6	4.5

Counts expressed as log10 cfu/ml or g. Geometric mean of three trials in each case.
Chlorine contact time (ambient temperature): Discs – 5 minutes; Skin – 20 minutes.

- Strains isolated from poultry carcases and tested separately.
- Material immersed in a 24 hour broth culture of the test strain. After draining, inoculated material left for five minutes and then subjected to a standard washing procedure to remove unattached cells.
- After treatment, attached cells recovered from stainless steel by mechanical agitation and collected in diluent. Recovery from skin by means of 'stomacher'.

Table 1. Effect of chlorine treatment on cells of Campylobacter jejuni attached to either stainless steel or chicken skin.

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less effective when cultured in laboratory media and the bacteria involved appear to be particularly oxygen sensitive.

Some studies have been concerned with defined treatment preparations comprising either a single type of organism or simple mixtures of a few types, as in conventional probiotics. The organisms tested have included bacteria resembling campylobacters that might compete for the same intestinal niche, coliform bacteria that utilised mucin for growth and inhibited C. jejuni in a plate test and a mixture of Lactobacillus acidophilus and Enterococcus faecium.

None of these preparations were particularly effective in small scale trials and, in the case of the coliforms, the protective effect was lost altogether when the campylobacter challenge dose was increased.

In other studies, the approach has involved dietary manipulation. For example, Fernandez et al. (2000) fed chicks on a wheat based diet supplemented with xylanase and found changes in the composition of intestinal mucin and cabohydrate expression of goblet cell glycoconjugates that were associated with a reduction in the viscosity of intestinal contents and lower numbers of C. jejuni, following challenge.

More recently, Heres et al. (2003) fed broiler chicks on a fermented liquid feed containing a large number of lactobacilli, a high concentration of lactic acid and having a pH of 4.0. The treatment reduced susceptibility to campylobacter infection in experimental trials, but not the level of caecal colonisation.

From all the work reviewed briefly above, it is clear that there is no fully effective intervention measure to control campylobacter colonisation on the farm.

There are indications, however, that measures can be taken to delay the onset of colonisation in broiler flocks and to reduce levels of intestinal carriage. More research is needed to establish the best means of achieving these goals under commercial conditions, with the aim of reducing current levels of end product contamination.

Carcases/skin	Treatment	Log10 reduction
Carcases	Drying/cooling, 20°C	0.3
Skin	Drying: 30°C, 15 minutes	1.0-2.0
Skin	Drying: 40°C, 15 minutes	2.0-3.5
Carcases	Crust freezing	0.4
Carcases	Steam: 100°C, 12 seconds	2.5

Table 2. Effects of physical decontamination treatments on campylobacter contamination of inoculated poultry carcases or skin portions (Dr J. E. L. Corry, personal communication).

Control in the processing plant

Because campylobacters are intestinal in origin, it is important in processing to reduce faecal contamination of carcases as far as possible. However, the impact of this approach is limited by the fact that levels of intestinal carriage in the live bird are generally much higher than those of other foodborne pathogens, with the consequence that carcase contamination is correspondingly greater.

Although campylobacters are relatively fragile organisms, it is evident that they are not eliminated by the scalding, washing and chilling processes that are universally applied or the use of superchlorinated processing water. The key to their survival as carcase contaminants is the ability to attach rapidly to skin and muscle surfaces, where they are suitably protected (Table 1).

Nevertheless, processing does reduce to some extent levels of carcase contamination. With most flocks, post-chill levels of campylobacter were found to be near or at the limit of detection for the rinse

method of sampling (10 cells/ml of rinse).

Chilling of carcases by immersion in super chlorinated water, as practised in the USA, reduces carcase contamination by approximately ten-fold, whereas air-chilling systems, which are popular in Europe for fresh chilled poultry, have no corresponding washing effect.

In the USA, but not in the European Union, it is possible to use chemical decontamination methods to further reduce carcase contamination.

Systems in current use, or under consideration, involve treatment with trisodium phosphate, acidified sodium chlorite or peroxyacetic acid. Because of the high rate of processing at the larger slaughterhouses, no suitable physical decontamination system has yet been developed, although several possible options are currently being studied (Table 2).

Of these, a drying stage at 40°C prior to air chilling or a brief steam treatment appear to be the most promising.

One aspect of processing that is currently receiving attention in the UK is the handling of live bird delivery crates.

These are washed at the processing plant before being returned to a farm to collect further birds, but are often found to be contaminated with campylobacters. It has been shown that the organisms can be transferred to the feathers of a previously campylobacter negative flock and thus add to the burden of carcase contamination.

In fact, the entire process of harvesting the birds and loading them onto the transporters significantly increased the chance of campylobacter contamination ($P<0.001$).

Current work is aimed at the development of improved methods of crate cleaning and disinfection. In many cases, attention also needs to be given to control of hygiene by the catchers, including appropriate changes of protective clothing and cleaning of catching equipment after use.

The relatively recent development of simple, rapid genotyping techniques for campylobacters is providing a new insight into the behaviour of the organisms during processing. Not only do these techniques show clearly the routes of carcase cross contamination, but also the extent to which particular strains can spread at any processing stage.

Furthermore, there are indications that some campylobacter sub-types survive processing better than others and this warrants further investigation, especially in relation to the public health significance of the more robust strains that contaminate the processing environment, survive the entire processing operation and go on to contaminate further flocks.

Conclusions

The availability of the complete genome sequence for C. jejuni has provided the impetus and opportunity for much of the current research on campylobacter that will eventually determine the basic biology of the organism and the mechanisms by which it can exist in different environments, including the alimentary tract of animal and human hosts. It will also have considerable value in elucidating campylobacter epidemiology and the significance of different sub-types.

Such information is vital to the development of appropriate control measures in livestock and meat production, especially for poultry, which is a major reservoir of the organism and for which effective controls are badly needed.

Microbiological risk assessment (MRA) is now a key part of the management of food safety risks throughout the world and, although the approach is still in its infancy, it is already being applied to campylobacter, despite the inherent uncertainties surrounding this organism.

One of the advantages of MRA is that it can be used to evaluate the effects of risk mitigation strategies and identify gaps in present knowledge. For example, freezing of poultry carcases had the biggest effect in decreasing the probability of human exposure per serving (66%) and the probability of infection per serving (96%). Other mitigation strategies had far less impact. Nevertheless, since freezing is not a realistic option for all poultry from the marketing viewpoint, and no fully effective control measure is available in production or processing, a different approach is required.

The aspects described in this article suggest that end-product contamination can be significantly reduced by the cumulative effects of measures taken at all stages of the supply chain.

The approach is in accordance with the farm-to-fork concept of controlling food safety and the introduction of Hazard Analysis Critical Control Point principles on poultry farms and in processing plants. It raises the question of whether there is a critical level of campylobacter contamination on processed carcases, below which the risk of human infection is greatly diminished.

In striving to improve control of campylobacter, all aspects of production and processing need to be considered. This may involve changes in current practices, such as elimination of flock thinning, scheduled slaughter of positive flocks and improved cleaning and disinfection of transport crates.

It may also lead to new processes, such as the development of a pre-chilling drying stage to enhance the die-off of campylobacters on carcases. However, some basic questions also need to be answered, for example why do some farms consistently produce campylobacter negative flocks, while others do not?

In Denmark, farmers that happen to produce campylobacter free poultry are paid a premium for these birds. Whatever changes are considered necessary in current production practices, a similar financial incentive to adopt them may also be required. ■

References are available from the author on request.