Campylobacter in Poultry Processing

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Campylobacters are Gram-negative bacteria with curved, rod-shaped cells and polar flagella. The unique spiral shape of the cell and the motility due to the flagella are useful characteristics to identify *Campylobacter* with phase contrast or dark field microscopy. Campylobacters grow at 42^{o}C and require low oxygen and a relatively high concentration of carbon dioxide in the environment. *Campylobacter jejuni* and *C. coli* are the species most commonly isolated from human gastroenteritis and from food sources. Several closely related species (*C. coli, C. fetus*, and *C*. *upsalienis*) may also cause disease in human but their incidence is rare.

Arcobacters, a group of bacteria related to *Campylobacter*, are seldom discussed in the US. Although *Arcobacter* has been linked to human disease, it appearance is not as important as campylobacters. We do not understand the epidemiology of *Arcobacter* as much as the epidemiology of *Campylobacter*. In addition, the methodology for isolation of *Arcobacter* is time consuming and therefore clinical laboratories and food microbiology laboratories do not actively search for it.

The Centers for Disease Control and Prevention (CDC), in collaboration with other organizations, such as State Health Departments, has been reporting the level of *Campylobacter* infections in humans through sentinel sites located across the US. Although recent reports by CDC proclaim that the incidence of bacterial foodborne pathogens is declining, *Campylobacter* is still the second most common bacterial pathogen—after *Salmonella*— in humans, with an incidence of 12.6 cases every 100,000 people for the year 2003. Many more cases go undiagnosed and therefore unreported.

Clinical Features of the Infections

Campylobacter produces isolated cases, with very few outbreaks. An outbreak is defined as two or more similar cases having the same source of infection. The most consistent and prominent feature of *Campylobacter* infection is diarrhea, sometimes bloody. The bloody diarrhea indicates that *Campylobacter* is an invasive pathogen that infiltrates the lining of the small intestine. Other typical symptoms of *C. jejuni* infections include fever, nausea and vomiting, abdominal pain, headache, and muscle pain. Most of the *Campylobacter* infections are mild, do not require hospitalization and may be self-limited. However, few *C. jejuni* infection can be severe and life threatening. Death is more common when other diseases (e.g., cancer, liver disease, immunodeficiency diseases) are present. It has been estimated that 500 persons die each year due to complications with *Campylobacter* infections. Some strains of *C. jejuni* have also been incriminated

in the production of Guillian-Barré syndrome, an acute neuromuscular paralysis, and Reiter syndrome, a reactive arthropathy.

The incubation period (the time between exposure and onset of symptoms) is typically two to five days. The illness usually lasts no more than one week; however, severe cases may persist for up to three weeks.

Sources of Campylobacters

Campylobacters live in the intestinal tract of healthy cattle, pigs and poultry. Campylobacters have been also isolated from pets and occasionally from streams, lakes and ponds. In commercial broiler chickens, campylobacters multiply without producing any disease to the chickens. The contamination of chicken meats with these pathogenic bacteria may occur when chickens are processed to convert them in human food. The first large baseline study of bacterial pathogens on poultry carcasses (years 1994-1995) revealed an incidence of 88% of *Campylobacter* bacteria with no apparent seasonal variation. Although figures from the most recent baseline study (years 1999-2000) have not been published, current scientific data indicate that there is still a high incidence of campylobacters in processed chicken carcasses.

Studies show that close to 20% of *Campylobacter* strains isolated from humans are genetically related to the strains isolated from poultry meats. These findings suggest that poultry meat is an important reservoir of campylobacters for humans. Yet, large *Campylobacter* outbreaks are not associated with raw poultry, but are associated with drinking unpasteurized milk or contaminated water. Other identified food vehicles include undercooked meats, mushrooms, cheese, shellfish, and eggs.

Contamination and Survival in Foods

Food becomes contaminated with intestinal material during processing. *C. jejuni* grows poorly on properly refrigerated foods, but survives refrigeration and grows on contaminated foods left out at room temperature. *Campylobacter* is sensitive to heat and common disinfection procedures. Pasteurization of milk, adequate cooking of meat and poultry and chlorination of water will destroy the organism.

Isolation of Campylobacters from Food

In the laboratory, campylobacters are presumptively identified by looking at the cell shape and motility with a phase contrast or a dark filed microscope. Positive results with catalase, oxidase and latex agglutination tests are used to confirm isolates to the genus level. Most of the times, these are the only tests used to confirm isolates as *Campylobacter* spp. The confirmation of isolates to the species level requires performing biochemical and physiological tests, such as hippurate hydrolysis and sensitivity to antibiotics.

Unlike *Salmonella* or *Escherichia coli*, *Campylobacter* and *Arcobacter* do not metabolize sugars and therefore few tests are available for species confirmation. Besides, the few available tests required trained personnel to avoid subjectivity and are time-consuming to perform. Few commercial laboratories offer a rapid identification system based on physiological and biochemical techniques for species identification.

New molecular tests, such as the polymerase chain reaction technique, are replacing the laborious physiological tests for identification of *Campylobacter* isolates. Yet, these molecular techniques can be run only in few dedicated laboratories.

Several methods, including enrichment and plate media, have been developed for the isolation of *Campylobacter* from commercial poultry carcasses. However, *Campylobacter* isolation methods have always been discussed when attempting to understand the meaning of the counts and incidence reported in the literature. The U. S. Department of Agriculture Food Safety and Inspection Service (USDA FSIS) has requested the National Advisory Committee on Microbiological Criteria for Foods to evaluate the methodologies used in the 1994-1995 and the 1999-2000 baseline studies. To date, no performance standard for *Campylobacter* has been established by USDA FSIS.

The collection of samples for *Campylobacter* studies in processing plant is done using the standard carcass rinse technique. Because of the large number of *Campylobacter* cells present per ml of carcass rinse, direct plating can be used to report the results in counts (CFU per ml of rinse). If the sample is enriched, the results are reported as positive or negative for *Campylobacter*. Both counts and positive/negative results are used to calculate the incidence (percentage positive) of campylobacters from a series of carcass samples.

Incidence and Control of Campylobacters in Chicken Carcasses

In general, there is a continuous decline in the number of campylobacters on commercial poultry carcasses from evisceration to immediately after the chiller. *Campylobacter* counts post-evisceration (pre-wash) are generally in the range of 2.5 to 3.7 log CFU per ml of carcass rinse. This range is typically found when sampling different processing plants or the same processing plant at different times.

The washing systems used during processing, some of which are called inside-outside bird washers (IOBW), may help reduce the number of *Campylobacter* spp. on carcasses. However, the reduction may not be of significance, or achieved consistently. In addition, the percentage of *Campylobacter* positive samples following the IOBW remains generally the same as pre-IOBW samples. In general, IOBWs reduce *Campylobacter* counts up to 0.7 log CFU/ml. The effectiveness of an IOBW to reduce *Campylobacter*, as well as other bacterial pathogens, depends greatly on the water volume/pressure and the level of chlorine in the water. These variables may be difficult to control consistently in commercial processing environments. The addition of an antimicrobial system, such as trisodium phosphate (TSP) or acidified sodium chlorite (ASC), to the washes produces a reduction of 1-1.7 log CFU/ml in the number of *Campylobacter* counts.

The combined used of IOBWs and chemical sprays have been found effective to remove visible fecal contaminations and to allow for a continuous online processing of commercial broiler carcasses. Although these washes and spray systems reduce *Campylobacter* spp., in some instances there have been no differences in the numbers of *Campylobacter* positives between pre-chill and post-chill samples. Some chemical interventions are now being applied after

chilling with successful reduction of *Campylobacter*. Applying chemicals after the chiller may have the advantage of using cold shock to potentiate the killing effect of the chemical.

The chiller is also a processing step that may account for the decrease in the number of *Campylobacter*. There appears to be a consistent reduction in *Campylobacter* counts due to the chilling process. However, a large number of post-chill carcasses are still positive for *Campylobacter* after enrichment. The chiller usually accounts for 0.8-1.3 log CFU/ml reduction in the number of *Campylobacter*, and 0 to 20% in the reduction of carcasses positive to *Campylobacter*. It is logical to believe that if the number of *Campylobacter* contaminating the carcasses pre-chill is still large, chances are the chilling process will not be able to significantly reduce the number of *Campylobacter* and/or the incidence of positive carcasses. We do not still understand the extent of contamination that carcasses may be subjected to in the chiller tank, if such a contamination exits.

The impact of the washing system, an antimicrobial application system and the chiller considered altogether account for a reduction of approximately 1.8 log CFU/ml of *Campylobacter* counts. Carcasses that undergo through this series of processing steps right after evisceration have a consistent reduction in the percentage of positive *Campylobacter* samples post-chill. However, if the level of *Campylobacter* spp. coming with the carcasses to the chiller tank is too high, the standard chilling process does not considerably reduce the level of contamination.

Although several intervention strategies and changes in processing have been incorporated to comply with the requirements brought about by HACCP regulations, a single intervention step would require a consistent reduction capability of up to a 3.7 log CFU/ml, with minimal impact on the organoleptic characteristics of the final product. The alternative approach, based on the use of several barriers or hurdles applied at different processing steps, is more currently used and appears to be more realistic for the control of *Campylobacter* spp. in poultry carcasses.

Besides the control measures at different stages of food processing, an important step in preventing and controlling campylobacteriosis is to adequately cook all poultry products. The most reliable method to ensure adequately cooking is to use a cooking thermometer.

Research institutions must continue to work together with the poultry industry to collect critical epidemiological information on how *Campylobacter* survives and transmits in foods. Improving our understanding of key epidemiological issues related to *Campylobacter* transmission in foods will certainly improve our chances of success in controlling this pathogen. Finally, we have to continue our efforts on the development of intervention technologies that can be applied at different stages during processing to reduce or eliminate the incidence of *Campylobacter* in poultry meat.

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