

that *Salmonella* spp. will not be transferred from one food (e.g., raw poultry) to another food (e.g., cooked chicken or celery that is to be used in a salad).

Employees must wash hands frequently when working in food production facilities and use hand washing methods that prevent the cross-contamination and transmission of *Salmonella* spp. and other pathogens in their feces to food.

### Infection Characteristics

The vegetative cells cause illness by multiplying in the intestinal tract. The illness is characterized by diarrhea, vomiting, fever, chills, and cramps. Because it is an infection, the presence of only a few cells can cause illness. The illness develops within 12 to 36 hours of eating food containing sufficient numbers of microorganisms. The illness can go on for a number of days or weeks, causing dehydration of victims and possibly causing death in the elderly and infants.

The number of microorganisms needed to cause illness varies with the type of *Salmonella* spp. species and the susceptibility or resistance of the host. As few as 1 or 2 viable cells in a meal for infants and immune-compromised individuals can make them ill, while healthy individuals might consume 100,000 to 10,000,000 viable cells in a meal without becoming ill.

### *Salmonella* spp. Food Infection

There are over 2,000 strains of *Salmonella*. All species and strains are pathogenic to humans. *Salmonella* spp. are found in the intestinal tract of infected animals and people. A variety of raw and processed foods have been found to carry *Salmonella* spp. Raw meat and poultry, shellfish, eggs and egg products, processed meat, and dried milk and cheese made from unpasteurized milk have been common sources of this microorganism. However, watermelon, cantaloupe, and fresh tomatoes have also been sources of *Salmonella* foodborne illness outbreaks in recent years.

*Salmonella* spp. grows in the presence or absence of air. *Salmonella* spp. grows well on or in food with a neutral pH of 6 to 7 and will multiply in food down to pH 4.1. These pathogenic bacteria can multiply on green tomatoes. However, organic acids (citric and/or acetic) found in commercial salad dressings and mayonnaise, at pH below 4.0, prevent multiplication and cause destruction *Salmonella* spp. in these products.

### *Salmonella* spp. Transmission

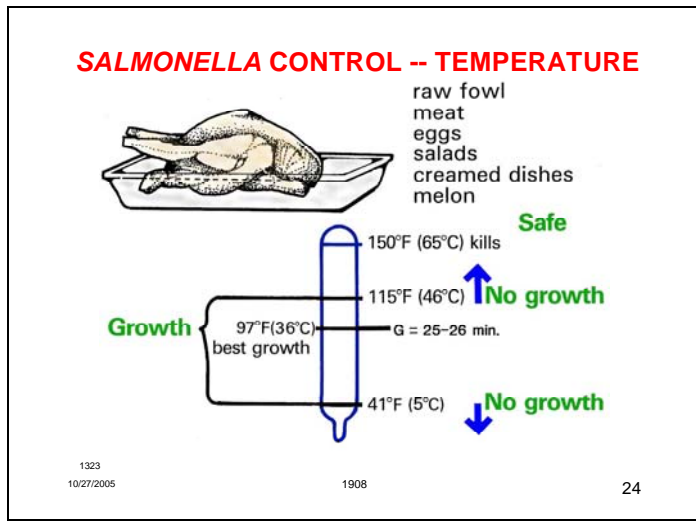
Many foods can become contaminated with *Salmonella*. Vegetables and melons become contaminated when: animal manure or human fecal material is used to fertilize the fields; contaminated water is used to irrigate crops; and people who harvest these crops are ill and transfer the bacteria to the vegetables and melons when they touch them.

Animals are infected with *Salmonella* spp. by the feed they eat or from the farm environment in which they raised. The infection spreads to other animals during transport. *Salmonella* spp. are transmitted from animal feces to carcasses and meat by equipment used in processing and by workers who touch the raw carcasses. Cross-contamination between clean carcasses and contaminated carcasses occurs in this way.

*Salmonella* spp. enter foodservice establishments on raw animal products or in the feces and on the fingers of infected employees. *Salmonella* spp. grow in food products when they are mishandled, undercooked, or recontaminated after cooking and then allowed to remain at dangerous temperatures.

### Transmission Prevention

To prevent cross-contamination, always clean and sanitize cutting boards and knives after each food product is prepared so



1323

### Salmonella spp. Control

An effective way to control *Salmonella* spp. is to store and prepare food at temperatures that minimize its growth, and/or to cook the food or food products to a temperature that will destroy the microorganism.

Up to 30% to 40% of all raw meat and poultry is randomly contaminated. Usually, the contamination is too low to make us ill (less than 10 microorganism per gram). But occasionally a highly contaminated item comes from the wholesale system.

There is no way to tell which item is the dangerous one. Washing meat and poultry only reduces bacteria by an insignificant number and will not really help as a safety control procedure. This practice contaminates the sink and kitchen with *Salmonella* spp. On the other hand, it is critical to double wash all fruits and vegetable to reduce contamination to a low level.

Multiplication (growth) of *Salmonella* spp. occurs optimally at 97°F, where it multiplies every 25 to 26 minutes. It begins to multiply at 41°F with a generation time of less than 3 days. At 50°F one generation time is 20 hours, and at 60°F the generation time is 6 hours. It stops multiplying at 115°F. If food is stored at less than 32°F, the temperature used to control *L. monocytogenes*, *Salmonella* spp. growth will be controlled.

*Salmonella* spp. is inactivated in the wet environment of at rates given in the following table. These temperatures and times can be used as a guide for inactivation of *E. coli* in hamburger.

Temperature	Ground Meat and Fish 5 D (100,000:1) kill	Roast Beef 6.5 D (3,160,000: 1) kill	All Poultry
130°F	86.2 min.	112 min	
140°F	8.6 min	11.2 min	
150°F	51.6 sec.	67 sec.	
160°F	5.2 sec	6.7 sec.	
165°F			15 sec.

Extreme care should be taken not to hold foods at the fast-multiplying temperatures of 80 to 110°F. After foods are cooked, they should be cooled from 135 to 70°F within 2 hours, followed by further to 41°F within 4 hours (6 hours total), according to the FDA Food Code. [USDA Guidelines recommend continuously cooling food, within 90 minutes after

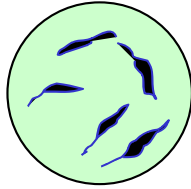
cooking, from 120 to 55°F within 6 hours, followed by further cooling to 40°F (no time limit) before boxing.]

*Salmonella* spp. can multiply down to a pH of 4.1. If a food product is made with raw unpasteurized eggs, it must be assumed to be contaminated with *Salmonella* spp. The pH of these food products must be adjusted with lemon juice, vinegar, or other suitable organic acid to prevent the multiplication of *Salmonella* spp. In fact, mayonnaise and other salad dressings normally have a pH of 3.5 to 3.8. After these products are prepared commercially, the mayonnaise and dressings are stored at room temperature for 3 days. During this time, the acid inactivates (destroys) the *Salmonella* spp. and other vegetative pathogens and makes these products safe.

Correct cleaning and sanitation of equipment and hands after handling raw animal products must be practiced to prevent the cross-contamination to cooked food that has few spoilage microorganisms and is very vulnerable to pathogen growth.

## CHARACTERISTICS OF *CAMPYLOBACTER JEJUNI*

- Grows best in small amount of air (oxygen).
- Grows between 86°F and 113°F.
- Survives chilling and freezing temperatures.
- Source is infected animals, birds, reptiles, and people.
- Common contaminant of raw foods of animal origin (poultry, pork, raw milk).
- Vegetative cells multiply in intestinal tract to cause illness.
- Infective dose = 400 to 500 cells in a portion of food.
- Vegetative cells killed by cooking.



1118  
10/27/2005

1908

25

1118

### *Campylobacter jejuni* - Characteristics Bacterial Characteristics

*Campylobacter jejuni* is a gram-negative, slender, curved to spiral rod that is motile by means of a single polar flagellum. It is an obligate microaerophile and grows optimally in an atmosphere containing 5-10% oxygen. It is relatively fragile and sensitive to environmental stresses of more than 21% oxygen, drying, heating, sanitizers, and acidic conditions. These microorganisms can survive refrigeration and freezing temperatures for a limited period of time.

#### Source

The nature and significance of *Campylobacter* spp. as a cause of illness in humans have been considered only recently. Since 1972, microbiological methods of isolating *Campylobacter* spp. have been developed. *C. jejuni* is now recognized as a common cause of gastroenteritis in humans.

It is commonly found as a pathogen in cattle, sheep, fowl, swine, and rodents. Incidents in which *C. jejuni* has been isolated as causing illness have resulted from the consumption of raw milk, undercooked poultry and pork. *Campylobacter* spp. can be spread by a contaminated water supply, and is carried by common household pets (particularly cats and dogs in poor health).

The presence of *C. jejuni* is high in fresh meat and may be as high as 100% in fresh poultry. The numbers of CFU (colony forming units) may vary from 10,000 CFU on a chicken wing to less than 1 CFU/cm<sup>2</sup> in raw pork and 1 to 10 CFU/cm<sup>2</sup> in raw beef (Genigeorgis, 1986)

#### Growth Conditions

**Temperature.** *C. jejuni* has been inappropriately termed thermophilic. It is neither thermophilic nor heat resistant. Doyle (1988) states that *C. jejuni* will not grow below 86°F. In 1981, Doyle et al. reported the temperature range for growth of *C. fetus* subsp. *jejuni* as 90 to 113°F. The optimum range for growth seems to be 107.6 to 113°F.

Ordinary cooking, which destroys *Salmonella* spp., also destroys *Campylobacter* spp. Doyle (1984) reported that heating meat to 140°F and holding it at this temperature is sufficient to destroy any *Campylobacter* present.

**pH.** The pH range for growth is 5.0-8.0.

**Atmosphere.** The organism is microaerophilic and requires an atmosphere of reduced oxygen for growth. Optimal growth conditions require 5 to 10% oxygen and 2 to 10% carbon dioxide. Because of its sensitivity to air and the relatively high temperature required for growth, growth of *C. jejuni* in foods is unlikely under ordinary conditions of food handling.

**Salt tolerance.** At 107.6°F, *C. jejuni* will grow in 1.5% table salt (sodium chloride, NaCl) and 0.5% NaCl, but not in 2% NaCl.

**Survival.** The organism does not grow in milk, but will survive 22 days at 39.2°F. If milk is held at 77°F, destruction of the microorganism occurs within 3 days. *Campylobacter jejuni* can survive on raw chicken held at - 4°F for more than 64 days (Oosterom et al., 1983).

#### Infective Dose

A pathogenic dose is usually given as ranging from 10<sup>6</sup> to as few as 400 to 500 organisms (Walker et al., 1986; FDA, 1993). Host susceptibility seems to dictate infectious dose. The pathogenic mechanisms of *C. jejuni* are still not completely understood. It does produce a heat-labile toxin that may cause diarrhea. It may also be an invasive organism (FDA, 1993)

#### Symptoms

The symptoms of illness caused by *C. jejuni* are similar to those caused by other enteric pathogens such as *Salmonella* spp., *Shigella* spp., and *Escherichia coli*. Stool cultures can provide positive identification.

Symptoms may be mild to quite severe and appear 2 to 5 days after ingestion of contaminated food or water. In severe cases, ingestion of *C. jejuni* produces severe, even bloody, diarrhea with fever, nausea, and severe abdominal pain. The occult blood may continue for 2 to 3 days after the symptoms are first observed.

Interestingly, children seem less seriously affected than adults who may appear to have ulcerative colitis. The illness may linger 1 to 2 weeks in all ages. Occasionally there may be a relapse characterized by a recurrence of abdominal pain and mild to severe gastroenteritis and bloody diarrhea, which may last for several weeks. The illness can also cause a reactive form of arthritis.

**Outbreak Example.** The following example appeared in MMWR 35(19):311-312, 1986.

*Campylobacter* Associated with Raw Milk Provided on a Dairy Tour - California. On October 3, 1985, students and teachers from northern California and some of their family members made a field trip to a San Joaquin County dairy. Of the 50 attendees from whom information was available, 23 (46%) became ill with *Campylobacter jejuni* infection.

Twenty-three (59%) of the 39 attendees who drank raw milk, and none of the 11 who did not drink it, became ill. Included among the cases was an infant who had been almost exclusively breast-fed and became ill after drinking a bottle filled with raw milk at the dairy. In addition, secondary cases occurred in 2 women who had not visited the dairy but who tended an infant who drank raw milk and developed *Campylobacter* gastroenteritis. Stool cultures from 1 asymptomatic and 8 ill

persons grew *C. jejuni*. Neither the cows nor the milk were cultured.

Of the 23 ill field-trip attendants, 96% reported diarrhea; 35%, abdominal cramps; 35%, fever; 26%, vomiting; and 22%, bloody diarrhea. Incubation periods ranged from 1 day to 10 days, but were 3 or 4 days in most cases. Symptoms most commonly lasted 5 days.

Numerous outbreaks of enteric diseases have occurred among school children given raw milk while on field trips to dairies in the United States. As a result, in January 1985, the U.S. Food and Drug Administration (FDA) issued a "milk advisory" to all state school officers recommending that children not be permitted to sample raw milk on such visits.

Healthy lactating cows can carry *C. jejuni* in the intestinal tract, providing an extrinsic source of contamination. Fourteen (61%) of 23 *Campylobacter* outbreaks reported to CDC from 1980 to 1982 were traced to consumption of raw milk. Since culture of diarrheal stools for *C. jejuni* became common, many raw milk-associated *Campylobacter* outbreaks involving thousands of cases have been reported.

Milk is an excellent vehicle for infection, because its fat content protects pathogens from gastric acid and because, being fluid, it has a relatively short gastric transit time. Present technology cannot produce raw milk that can be assured to be free of pathogens. Milk must be pasteurized to ensure the destruction of *Campylobacter jejuni*. In Scotland, the incidence of illness due to *C. jejuni* has decreased markedly since 1983 when the sale of raw milk was banned.

*Campylobacter jejuni* is present in 30% of raw pork, 80-100% of raw poultry, and 10% of all raw, unpasteurized milk and dairy products. It is found on raw vegetables fertilized with animal or human fecal material.

### Incidence

Bennett et al., 1987 estimated an annual incidence of 2,100,000 cases of *Campylobacter* illness in the U.S. resulting in 2,100 deaths. The annual incidence as estimated by the FDA (1993) is 2 million to 4 million cases a year. Roberts and van Ravenswaay, 1989 estimated the annual cost of campylobacteriosis at about 1 billion dollars.

### References:

- Adams, M.R. and Moss, M.O. 1995. Food Microbiology. The Royal Society of Chemistry. Cambridge, U.K.
- Archer, D.L. and Young, F.L. 1988. Contemporary Issues: Diseases with a food vector. Clin. Microbiol. Rev. 1(4):377-398.
- Benenson, A.S., Ed. 1990. Control of Communicable Diseases in Man. American Public Health Assoc. Washington, D.C.
- Bennett, J.V., Scott, D.H., Rogers, M.F., and Solomon, S.L. 1987. Infectious and parasitic diseases. In The Burden of Unnecessary Illness. Amler, R.W. and Dull, H.B., Eds. Oxford Univ. Press. New York, NY.
- Doyle, M.P. 1984 *Campylobacter* in foods. Chapt. 14 in *Campylobacter Infections in Man and Animals*. Butzler, J.P., Ed. CRC Press. Boca Raton, FL.
- Doyle, M.P. 1988. *Campylobacter jejuni*. Food Technol. 42(4):187.
- Doyle, M.P. and Roman, D.J. 1981 Growth and survival of *Campylobacter fetus* subsp. *jejuni* as a function of temperature and pH. J. Food Protect. 44(8):596-601.
- FDA. 1993. HACCP. Regulatory Food Applications in Retail Food Establishments. Dept. of Health and Human Services. Division of Human Resource Development. HFC-60. Rockville, MD.
- Franco, D.A. 1989. Campylobacteriosis. J. Environ. Health 52(2):88-91.
- Genigeorgis, C. 1986. Problems associated with perishable processed meats. Food Technol. 40(4):140-154.
- Namchamkin, I. *Campylobacter jejuni*. 1997. In Doyle, M. P., Beuchat, L. R., and Montville, T. J., Eds. Food Microbiology: Fundamentals and Frontiers. American Society of Microbiology. Washington, D.C. pp.159-161.
- Oosterom, J., DeWilde, G.J.A., DeBoer, E., DeBlaauw, L.H., and Karman, H. 1983. Survival of *Campylobacter jejuni* during poultry processing and pig slaughtering. J. Food Protect. 46(8):702-706.
- Roberts, T and van Ravenswaay, E. 1989. The economics of safe guarding the U.S. Food Supply. USDA Ag. Info. Bulletin. No. 566:1-6.
- Stern, N. J. and Kazmi, S.U. 1989. *Campylobacter jejuni*. In Foodborne Bacterial Pathogens. Doyle, M.P., Ed. Marcel Dekker, Inc. New York, NY.
- Walker, R.I., Caldwell, M.B., Lee, E.C., Guerry, P., Trust, T.J., and Ruiz-Palacios, G.M. 1986. Pathophysiology of campylobacter enteritis. Microbiol. Rev. 50:81-94.

