

CLOSTRIDIUM PERFRINGENS

THE ORGANISM/TOXIN

Grows best when there is little or no oxygen. It exists in 2 forms: vegetative (growth phase) and spore form (survival phase). It does not readily form spores in food; these are mostly formed in the intestine. It is during spore formation that enterotoxin is produced. Most cases of *C. perfringens* food poisoning are caused by type A strains.

GROWTH AND ITS CONTROL

Growth:

Temperature: Optimum growth 43-47°C, range 12-50°C. *C. perfringens* has a generation time of less than 7.1 minutes in its optimum temperature range.

Optimum temperature for enterotoxin production, 35-40°C.

pH: Optimum growth is between pH 6.0 and 7.0 which is the pH range of many cooked meat and poultry products. Growth is possible over the pH range of 5.5 to 9.0. Good sporulation occurs between pH 6.0 and 8.0.

Atmosphere: Growth is best under anaerobic conditions, however, *C. perfringens* is less strictly anaerobic than other clostridia.

Water activity: The minimum a_w for growth is from 0.93-0.97 depending on the solute. Spore germination occurs in the same a_w range as growth.

Survival:

Temperature: Vegetative cells are readily killed by heating but spores are very heat resistant. Some spores survive boiling for 1 hour.

Vegetative cells are highly susceptible to freezing temperatures (93.5% were killed after 30 days at minus 17.7°C). They decline more slowly under refrigeration. Spores, however, survive both refrigeration and freezing.

Atmosphere: Growth inhibited by Eh values above 300mV.

Water Activity: Spores are highly resistant to desiccation but vegetative cells are not very tolerant of low a_w .

Inactivation (CCPs and Hurdles):

Temperature: *C. perfringens* spores will survive boiling for >1 hour. D values for spores at 100°C vary between strains from 0.31 min to >38 min. D time for vegetative cells at 60°C = 5.4-14.5 min. Heating food to between 70 and 80°C followed by cooling will induce germination of spores.

C. perfringens enterotoxin is inactivated by heating for 5 min at 60°C.

C. perfringens will not grow at <12°C (a most important CCP for food safety).

pH: Cells will die after several days below pH 5.0 and above pH 8.3

Water activity: 6-8% NaCl inhibits growth.

Preservatives: (NB: Some of the preservatives discussed here may not be permitted in New Zealand). Growth is inhibited by sodium nitrate at a concentration of 10,000 ppm or sodium nitrite at 400 ppm, both of which grossly exceed acceptable levels. By applying more than one preservation factor at commercially acceptable levels *C. perfringens* growth can be prevented, e.g. the NaCl content required can be reduced to 3% plus vacuum packaging to delay growth in cooked beef. A combination of the curing salts of sodium chloride and sodium nitrite can inhibit growth. As the concentration of NaCl increases from 3-6%, the levels of nitrite needed decrease from 300-25 µg/ml.

Sanitisers/Disinfectants:

(These products must be used as advised by the manufacturer)

High concentrations of ethanol result in spore injury and death.

Residual chlorine in a water reticulation system will not inactivate the organism.

5 mg/litre free chlorine produced a 1.4 log unit reduction in 4h of exposure, while a mixed oxidant system resulted in a >3 log unit reduction in the same time.

The organism is insensitive to inactivation by ozone. (N.B. The absence of a sanitiser/disinfectant from this section does not necessarily imply that is ineffective).

Radiation: D values for spores vary from 1.2 to 3.4 kGy depending on the strain.

THE ILLNESS

Incubation: Symptoms can occur between 6 and 24 hours after eating contaminated food. Usual onset time is 10 - 12 hours.

Symptoms: Profuse watery diarrhoea with severe abdominal pain that subsides within 24 hours or less. Vomiting and nausea are rare. Recovery is rapid, usually within 24 hours.

Estimated hospitalisation rate 0.3%, case fatality rate 0.05%.

Condition: Gastroenteritis or *C. perfringens* enteritis. Fatal cases are rare and are usually associated with debilitated or institutionalised patients, especially the elderly.

Toxins: Toxins are produced in the intestine but small amounts may be produced in some foods and this may contribute to the early onset of symptoms in some cases of *C. perfringens* food poisoning. Studies

have however, shown that normally if bacteria have grown to large enough numbers to produce toxin, the food would be obviously spoiled.

At Risk Groups: All people are believed to be susceptible to infection, but the intensity of symptoms may vary between individuals.

Long Term Effects: None

Dose: Large numbers of cells have to be ingested to cause food poisoning (at least 10^6 /g of food).

NZ Incidence: In the Annual Summary of Outbreaks in NZ (1999), 17 outbreaks were attributed to *C. perfringens* (167 cases), in 1998 there were 22 outbreaks (107 cases).

Treatment: Usually no treatment is given.

SOURCES

Human: *C. perfringens* is a minor component of the normal faecal flora of healthy humans although food handlers are not thought to be a source of food contamination as the organism already exists on the at-risk foods. Levels of *C. perfringens* in healthy elderly individuals can be elevated.

Animal: A normal inhabitant of intestinal contents of animals. Contamination of carcasses occurs at slaughter. Animal foods are the most common reservoirs of infection.

Food: *C. perfringens* is found in a large variety of foods including raw, dehydrated and cooked foods.

C. perfringens food poisoning is often associated with settings involving large quantities of food, especially meat and poultry dishes, which are prepared in advance and allowed to cool slowly or are inadequately refrigerated. Rolled meats and stuffed poultry provide favourable growth conditions as contamination is transferred into the centre where heat penetration and cooling are slow and anaerobic conditions exist. Pies provide ideal conditions for growth as the pastry excludes air. The cooking of thick soups, stews and gravies drives off air, creating ideal anaerobic environments during cooling for germinating spores to grow. Non-meat dishes such as vegetable curry and soups have also been implicated in cases of disease.

Environment: *C. perfringens* is widely distributed in soil, dust and vegetation. Can be found at levels of 10^3 to 10^4 cfu/g in soil.

Transmission Routes: Ingestion of contaminated foods.

OUTBREAKS AND INCIDENTS

Outbreaks: Outbreaks of *C. perfringens* food poisoning result from eating foods that are contaminated with large numbers of vegetative cells of enterotoxigenic strains of the organism. The symptoms are produced when ingested cells sporulate and induce toxin in the intestine. Virtually all outbreaks are caused by failure to properly refrigerate cooked foods, especially when prepared in large portions. Episodes of *C. perfringens* food poisoning occur throughout the year with no particular seasonal preference.

New Zealand:

Roast turkey rolls: 50 cases. Control measure failures: inadequate cooling, inadequate reheating.

Chicken à la King: 46 cases. Control measure failures: cooking a large amount of food in advance, inadequate cooling, inadequate reheating.

Roast pork: 66 cases. Control measure failures: poor temperature control of raw product, uncontrolled cooking temperatures, inadequate cooling.

Wontons: 12 cases. Control measure failures: inadequate cooling, inadequate reheating.

Roast chicken with sausage meat stuffing: 29 cases. Control measure failure: inadequate cooling, inadequate reheating.

Overseas:

Gravy: 600 cases. Control measure failures: inadequate cooling, inadequate reheating.

Cold cooked chicken: 241 cases. Control measure failures: inadequate cooling, storage at incorrect temperature.

Chicken vol-au-vent: 85 cases. Control measure failures: inadequate cooling of chicken, storage at incorrect temperature, insufficient reheating of filled vol-au-vent.

Roast lamb: 12 cases. Control measure failures: inadequate cooling, storage at incorrect temperature.

Roast pork: 33 cases. Control measure failures: inadequate cooling, storage at incorrect temperature.

Minestrone soup: 32 cases. Control measure failures: inadequate cooling, insufficient reheating.

Spinach boiled with fried bean curd: 30 cases. Control measure failures: inadequate cooling, storage at incorrect temperature, insufficient reheating.

ADEQUATE PROCESSING GUIDELINES

N.B. These guidelines have been derived from published information. Industry is advised to ensure that processing steps they are using are adequate to meet their particular food safety objectives.

Cook meats to:	Internal temperature reached	Time
Minced meats (beef, veal, lamb, pork) + pork cuts	71°C	15 sec
Minced poultry	74°C	"
Meat cuts (beef, veal, lamb), fish, seafood	63°C	"
Poultry, breast	77°C	"
Poultry, whole	82°C	"
Whole roasts (ham, corned beef, pork, beef)	54°C	121 min
"	56°C	77 min
"	57°C	47 min
"	58°C	32 min
"	59°C	19 min
"	60°C	12 min
"	61°C	8 min
"	62°C	5 min
"	63°C	3 min
Cool cooked foods at room temperature until:	≥55°C	
Continuously cool cooked foods under refrigeration to achieve a reduction of:	55°C to 25°C	In less than 5 hrs
Followed by:	25°C to 5°C	In less than 10 hrs
Hold foods at	≤ 5°C or ≥ 60°C	
Reheat cooked foods to	74°C	Instantaneous
Reduce pH of food to ≤ 5.5		

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