

# ESCHERICHIA COLI O157:H7

## THE ORGANISM/TOXIN

A pathogenic variant of an organism that is generally regarded as innocuous. The number of cases of infection in New Zealand is rising, but the transmission routes remain obscure. Can grow in the presence or absence of oxygen. In most cases, can be distinguished from non-pathogenic *E. coli* by simple tests.

## GROWTH AND ITS CONTROL

### Growth:

**Temperature:** Optimum 37°C, minimum 7-8°C, maximum 46°C. Some isolates can grow in raw milk at 8°C.

**pH:** Optimum 6-7, range 4.4 to 9.0. Doubling time approx. 0.4h at 37°C. The limit at the low pH end depends on the acidulant used. Mineral acids such as HCl are less inhibitory than organic acids (e.g. acetic, lactic) at the same pH.

Growth was inhibited in the presence of 0.1% acetic acid (pH 5.1).

**Atmosphere:** Can grow in the presence or absence of oxygen. Growth can occur in vacuum-packed meat at 8 and 9°C, but not when the meat is packed under 100% CO<sub>2</sub>. At 10°C growth was not inhibited under 100% N<sub>2</sub> or 20% CO<sub>2</sub>:80% N<sub>2</sub> but was under 100% CO<sub>2</sub>. Growth on lettuce was not inhibited by the presence of 30% CO<sub>2</sub>, or under 97% N<sub>2</sub>:3% O<sub>2</sub>.

**Water activity:** Optimum growth is at  $a_w=0.995$  minimum  $a_w=0.950$

### Survival:

**Temperature:** Survives well in chilled and frozen foods. For example little change was noted in numbers in hamburgers stored at -20°C for 9 months. Some reports indicate an initial <1 log die off followed by a slow decline in numbers.

**pH:** Can survive in low pH (down to 3.6) environments. In fact the organism dies slowly under these conditions and persistence is proportionate to the degree of contamination. For example numbers reduced by only 100 fold after 2 months storage at 4°C on fermented sausage of pH 4.5. Prior exposure to acidic conditions can increase acid tolerance.

Has been shown to survive stomach pH (1.5) for periods longer than that required to clear an average meal (3 hours).

**Atmosphere:** An atmosphere of 100% CO<sub>2</sub> enhanced survival of uninjured cells at both 4 and 10°C. Survival on fermented meat was equivalent when packed under air or under vacuum.

**Viable but Non-Culturable (VNC) Cells:** Evidence indicates that low temperature is the primary signal for entry into the VNC state in water.

**Water Activity:** Survives on dry alfalfa seeds for weeks depending on storage temperature (longer survival at lower temperatures).

### Inactivation (CCPs and Hurdles):

**Temperature:** Rapidly inactivated by heating at 71°C (recommended temperature for hamburger cooking in the USA, in the UK it is 70°C for 2 min).

$D_{54.4} = 40$  min.  $D_{60} = 0.5-0.75$  min (4.95 min in minced beef).  $D_{64.3} = 0.16$  min. Thermal resistance is higher in foods of high fat content or that are packed under low oxygen (<2%) atmospheres.

Freeze thawing can lead to a reduction in numbers but the effect is strain dependent. D times may increase if the organism is heat shocked prior to heat treatment.

**pH:** Inactivation is dependent on the pH, acidulant and temperature. For example, when added to mayonnaise (pH 3.65) there was a 7 log decrease in numbers at 25°C, but only a 3.5-4.5 log decrease at 4°C.

**Water activity:** Withstands desiccation well and has caused disease through carriage on venison jerky.

**Preservatives:** (NB: Some of the preservatives discussed here may not be permitted in New Zealand). 8.5% NaCl inhibits growth at 37°C, growth retarded above 2.5%. The amount of salt required for inhibition reduces as other factors such as temperature and pH become sub-optimal. For example 5% salt inhibited *E. coli* O157:H7 at 12°C.

The presence of 0.1% sodium benzoate rapidly reduces the population of the organism in apple juice, while 0.1% potassium sorbate was ineffective. Inhibited by 500 ppm eugenol (a component of liquid smoke).

Does not have any enhanced survival capabilities when exposed to other preservatives.

**Sanitisers/Disinfectants:** (These products must be used as advised by the manufacturer).

Spraying lettuce, contaminated with inoculated bovine faeces, with a solution containing 200 ppm chlorine was no more effective at decreasing numbers than spraying with water.

Gaseous glacial acetic acid decontaminated mung beans inoculated with this organism. Alfalfa beans inoculated with 100-1000 cells/g were not decontaminated by a number of disinfectants but Ca(OCl)<sub>2</sub> (≥2,000 ppm), acidified ClO<sub>2</sub> (≥100 ppm), H<sub>2</sub>O<sub>2</sub> (≥0.2%), acidified NaClO<sub>2</sub> (≥500 ppm) and Na<sub>3</sub>PO<sub>4</sub> (≥1%) all resulted in a significant decrease

in numbers.

20,000 ppm chlorine results in a 2.0 to 2.1 log reduction in numbers on alfalfa seeds after exposure for 30 min.

Using a 5D reduction in numbers as a goal, use of peroxyacetic acid, chlorine dioxide or chlorine-phosphate buffer was insufficient to sanitise surface contaminated whole apples.

In the absence of organic matter benzalkonium chloride, chlorhexidine gluconate containing nonionic surfactant, ethanol and hot (70°C) water are effective sanitisers.

Electrolyzed oxidising water may be an effective disinfectant.

Standard water chlorination is effective against this organism, although suspended solids reduce efficacy. (NB the absence of a disinfectant from this section does not necessarily imply that it is ineffective).

**Radiation:** Sensitive to UV and  $\gamma$  irradiation. D (kGy) approx. 0.31 frozen, 0.24 refrigerated in ground beef. A 2-3 kGy dose is sufficient to decontaminate meat.

## THE ILLNESS

**Incubation:** 3 to 9 days (mean 4 days) following ingestion of the bacteria.

**Symptoms:** The organism invades the gut and then produces a toxin. The results of infection can range from being asymptomatic to kidney disease and death. In more serious cases there is a period of bloody diarrhoea followed by HUS (see below). The elderly may suffer from TTP (see below).

**Condition:** More serious forms of the disease include:

*Haemorrhagic Colitis (HC):* Bloody diarrhoea, severe abdominal pain, vomiting, no fever.

*Haemolytic Uraemic Syndrome (HUS):* Characterised by renal failure and the consequences of that. Kidneys are attacked by toxins released by the organism. HUS is normally associated with children. HUS follows HC and produces kidney dysfunction, seizures, coma, death. Approximately 10% of children who become infected by *E. coli* O157:H7 develop HUS and of these the case fatality rate can be restricted to less than 10% if appropriate care is given. Only one death to date in NZ has been caused by HUS, representing a death rate of around 1% of STEC cases.

*Thrombocytopenic purpura (TTP):* A version of HUS most often experienced by the elderly. Involves loss of platelets, skin colouration, fever and nervous system disorder (seizures and strokes) in addition to HUS signs and symptoms. There is no prior episode of diarrhoea.

Illness lasts from 2-9 days. Approximately one third of cases are hospitalised. Death rate, <5% in the

USA. Only one death to date in NZ by TTP, representing a death rate of around 1% of STEC cases.

**Toxins:** No toxins are produced in foods, but they are in the gut of infected people. Cause kidney failure.

**At Risk Groups:** Can affect any age group but most often causes disease in infants (< 4 years) and the elderly (>65 years).

**Long Term Effects:** HUS: kidney problems, hypertension, neurological deficits.

**Dose:** Foods with as low as 0.3-0.4 cells/g have been involved in outbreaks. However, the number of cells required to give a 50% probability of disease has been estimated at  $5.9 \times 10^5$ .

**NZ Incidence:** 1.8 cases/100,000 in 1999, 1.3 in 1998. N.B. This is for *E. coli* O157:H7 and all other shiga toxin-producing *E. coli*, but serotype O157:H7 accounts for around 90% of the notified cases.

**Treatment:** Dialysis, maintenance of fluid balance and treatment of hypertension in cases of HUS.

## SOURCES

**Human:** Faecal-oral person-to-person transmission is often reported in family members of cases who contracted the disease from food or water.

**Animal:** Found in the guts of ruminant animals. Cows and cattle are considered primary reservoirs but sheep and deer may also carry the organism. One NZ study found *E. coli* O157:H7 in 2 of 371 faecal samples from dairy cows. Carriage of the organism by cattle in the USA is generally considered to be low, but estimates of prevalence rise with improving techniques. Calves are thought to shed the organism more often than adult cattle. In North America the prevalence in cattle is highest during spring and late summer.

**Food:** Has not been detected in retail foods in New Zealand. Incriminated foods overseas have usually been contaminated by cattle manure. Foods involved in overseas outbreaks have included hamburgers, other meat products, apple juice, salads, bean sprouts, raw milk, cheese, melons, lettuce and yoghurt.

**Environment:** Water contaminated from faecal sources has been the vehicle involved in a number of large outbreaks overseas. Such waters have included reticulated drinking water and swimming/paddling pool water. Two cases in New Zealand have been attributed to the consumption of contaminated water (neither was reticulated water). The organism has been shown to survive for 150 days in soil and 90 days in cattle faeces. It can also survive for at least 4 months in cattle drinking trough sediment.

**Transmission Routes:** In summary, any food or water source that has been contaminated by the

faeces of a ruminant animal.

Secondary transmission is also common. Poor personal hygiene can also result in infection; 8 pop festival attendees became infected after the event which was held in a muddy paddock on which cattle had recently been grazed.

## OUTBREAKS AND INCIDENTS

**Outbreaks:** While there have been small family clusters in New Zealand there have been no recognised outbreaks. The following are examples from overseas, mainly the USA.

**Hamburgers:** 26 cases, 19 hospitalised. Control measure failure: inadequate heat treatment.

**Hamburgers:** 11 cases. Control measure failure: inadequate heat treatment.

**Drinking Water:** 243 cases, 32 hospitalised, 2 HUS, 4 died. Control measure failure: reticulation system compromised.

**Hamburgers:** 731 cases, 178 hospitalised, 56 HUS, 4 died. Control measure failure: inadequate heat treatment.

**Salami:** 19 cases, 5 HUS. Control measure failure: contaminated raw ingredients, no effective CCPs in manufacture.

**Yoghurt:** 16 cases, 5 HUS. Control measure failure: post pasteurisation contamination of the milk used.

**Radish Sprouts (suspected):** 6,309 cases, peaks of 534 hospitalised and 101 with HUS, 2 died. Control measure failure: (possible) contamination of the raw seeds

**Epidemiological studies:** The consumption of ground (minced) beef products has been found to be associated with disease in sporadic cases of *E. coli* O157:H7 infection.

## 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, hamburger patties (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	"
Hold foods at	≤ 5°C or ≥ 60°C	
Reheat cooked foods to	74°C	Instantaneous
Acidify foods to pH 3.6 or below		
Avoid cross contamination from raw to ready-to-eat foods		
Thoroughly wash all fruit and vegetables		

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