Imported food risk statement

Fresh raw beef and beef products and Shiga toxin-producing *Escherichia coli*

Scope: Fresh raw (chilled and/or frozen) beef and beef products, including carcasses, whole muscle meat, bone-in and non-intact cuts (e.g. mince and trim) and offal from BSE and biosecurity approved countries. Excludes all products not permitted under BSE and biosecurity restrictions such as brain and spinal tissue, blood and blood products, reproductive organs and natural casings.

Recommendation and rationale

Does Shiga toxin-producing *Escherichia coli* (STEC) in imported fresh raw beef and beef products present a potential medium or high risk to public health that may require additional management measures:

☑ *Yes*

☐ *No*

Rationale:

- STECs are very infectious organisms and cause potentially life threatening illness in humans with substantial and/or chronic sequelae.
- There is very strong evidence that STECs have caused foodborne illness associated with beef and beef products.
- The method of producing fresh raw (chilled and/or frozen) beef introduces contamination into the food and does not contain a pathogen elimination step. Some beef products (i.e. trim and offal) may contain higher levels of contamination as further processing steps (i.e. mincing) can introduce contamination into the product.
- HACCP based quality assurance systems are required throughout the entire supply chain to minimise the potential for contamination and subsequent growth of any contaminating pathogens.

General description

Nature of the microorganism:

E. coli are facultative anaerobic, Gram-negative, rod-shaped bacteria. They are found in warm-blooded species including humans as part of the normal intestinal flora (FSANZ 2013). The majority of *E. coli* are harmless, however some have acquired specific virulence attributes, such as Shiga toxin-producing *E. coli* (STEC), which can cause severe infection including haemolytic uraemic syndrome (HUS) and death in humans (FDA 2012). Major foodborne pathogenic STEC strains include O26, O45, O103, O111, O121, O145, O157 (FDA 2012) and O104 (ECDC/EFSA 2011). Ruminants, in particular cattle and sheep, are the main animal reservoir of STEC. STEC also colonises other species, although the incidence is lower than in ruminants (FSANZ 2013; Meng et al. 2013). STEC are transmitted by the faecal-oral route by either consumption of contaminated food or water, from direct contact with infected animals or via person-to-person contact (Gyles, 2007).

Growth of *E. coli* can occur at temperatures ranging between 7 – 46°C, pH of 4.4 – 10.0 and a minimum water activity of 0.95 when other conditions are near optimum (FSANZ 2013). Experimental studies have shown that *E. coli* O157:H7 can grow in minced beef at temperatures between 6 and 45°C (Tamplin et al. 2005). Some STEC strains are able to survive at pH 2.5 – 3.0 for over four hours, although this can depend on the strain and type of acid present. For example, *E. coli* O157:H7 can survive in a growth medium adjusted to pH 4.5 with hydrochloric acid but not when adjusted to the same pH with lactic acid (FSANZ 2013; ICMSF 1996). STECs are able to survive frozen storage at -20°C but are readily inactivated by thorough cooking (FSANZ 2013; Meng et al. 2013). STECs, like all microorganisms, can develop resistance traits in response to various stresses including heat, acid and use of antimicrobial substances.

General description

Adverse health effects:

STEC can cause potentially life threatening illness with substantial and/or chronic sequelae. People of all ages are susceptible to infection with STEC, with the young and the elderly more susceptible and more likely to develop serious symptoms and/or sequelae (FSANZ 2013). Infection with antimicrobial resistant STEC strains may result in more severe illness which may be more difficult to treat.

Symptoms include diarrhoea, abdominal pain, vomiting and fever. The onset of illness is typically three to eight days after infection with most patients recovering within 10 days. More severe STEC infections (haemorrhagic colitis) are characterised by severe abdominal cramps and bloody diarrhoea, with approximately 3 – 7% of haemorrhagic colitis cases developing haemolytic uraemic syndrome (HUS). HUS is characterised by acute kidney injury, thrombocytopenia and haemolytic anaemia. Children under five years of age are more susceptible to developing HUS following STEC infection. About 30% of patients with HUS develop minor sequelae such as proteinuria, and 5% of patients develop severe sequelae such as stroke and kidney failure. The fatality rate of HUS is 3 – 5% (FDA 2012; FSANZ 2013; Meng and Schroeder 2007).

It is generally accepted that low levels (10 – 100 cells) of STEC can cause illness. Depending on the food matrix and strain of STEC, illness may occur at exposure to even lower levels of STEC (FDA 2012; FSANZ 2013).

Consumption patterns:

The 2011 – 2012 Nutrition and Physical Activity Survey (part of the 2011 – 2013 Australian Health Survey) provides detailed national data on consumption of foods in Australia.

Consumption of beef (excluding mixed foods that contain beef and beef products)

In the survey, 15% of children (aged 2 – 16 years), 18% of adults (aged 17 – 69 years) and 21% of people aged 70 and above reported consumption of beef on the day of the survey. Beef consumption can be divided into minced meat, whole muscle cuts and offal. Nine percent of children (aged 2 – 16 years), 7% of adults (aged 17 – 69 years) and 9% of people aged 70 and above reported consumption of minced meat. Seven percent of children (aged 2 – 16 years), 12% of adults (aged 17 – 69 years) and 11% of people aged 70 and above reported consumption of whole muscle cuts. Less than one percent of adults (aged 17 – 69 years) and <1% of people aged 70 and above reported consumption of offal. No children (aged 2 – 16 years) reported consuming offal (Australian Bureau of Statistics 2011). No data was available for consumption of raw or minimally cooked beef and beef products.

Consumption of mixed foods containing beef

In the survey, 51% of children (aged 2 – 16 years), 48% of adults (aged 17 – 69 years) and 43% of people aged 70 and above reported consumption of mixed dishes containing beef on the day of the survey. These beef dishes can be divided into dishes containing whole muscle meat, minced meat or offal. Forty percent of children (aged 2 – 16 years), 32% of adults (aged 17 – 69 years) and 26% of people aged 70 and above reported consumption of minced meat dishes. Fifteen percent of children (aged 2 – 16 years), 22% of adults (aged 17 – 69 years) and 20% of people aged 70 and above reported consumption of whole muscle meat dishes. Less than one percent of children (aged 2 – 16 years), <1% of adults (aged 17 – 69 years) and <1% of people aged 70 and above reported consumption of mixed dishes containing offal (Australian Bureau of Statistics 2011).

Risk factors and risk mitigation:

Production of fresh raw beef and beef products does not include a pathogen elimination step. Controls are needed throughout the entire supply chain to minimise the potential for contamination and subsequent growth of any contaminating pathogens. Quality assurance (QA) programs and/or application of a Hazard Analysis and Critical Control Point (HACCP) system should be applied in the design and implementation of hygiene measures throughout the entire food chain including animal production, transport, lairage and slaughter and dressing operations (Codex 2013). Microbiological testing, for example validated process hygiene criteria or appropriate environmental testing, may be helpful in verifying the effectiveness of HACCP-based QA programs.

Ruminants are the main reservoir of STECs, which reside in the animal without causing any visible adverse effects. The presence in a herd or animal can only be detected by microbiological testing. During animal production, the key inputs and activities contributing to the presence and level of STECs include the health of the animal, stress, inputs such as feed, water and veterinary medicines, and management of environmental and biosecurity factors, including transport, saleyards and lairage. During processing, contamination may occur from external sources (i.e. the animal or the environment), or internal sources during slaughter and dressing operations (FSANZ 2009a). Good agricultural practices, good hygienic practices and good manufacturing practices should be employed throughout the production chain.

General description
Pathogen load in the animal can increase due to illness or stress. Stress occurs when animals are deprived of feed and water and during transport, holding and handling procedures. These stressors can lead to increased pathogen shedding, contamination of the transport vehicle and the lairage, and subsequent transfer of the contamination to other animals (FSANZ 2009a; Adam and Brulisauer 2010; ICMSF 2005). Conditions for transport and holding animals prior to slaughter should minimise the potential for cross-contamination with foodborne pathogens. QA programs should be implemented to achieve the appropriate conditions for transport and lairage (Codex 2013). The competent authority determines the procedures used during anti-mortem and post-mortem inspections to ensure only healthy, sufficiently clean and appropriately identified animals are slaughtered and meat produced for human consumption is wholesome and safe (Codex 2013). During slaughter or fabrication (e.g. quartering, boning and packing) contamination of the external surface of the carcass can occur (Adam and Brulisauer 2010; FSANZ 2009a). Stunning and bleeding can lead to contamination of the slaughtering and processing environment and should be performed in such a manner as to minimise contamination. During slaughter and dressing, hocks, head, hide and viscera are removed and bunging is performed to minimise faecal leakage onto the carcass and processing environment. The objective is to undertake these processes with as little contamination as possible of the exposed carcass tissue and of edible offal. Decontamination processes, such as trimming and washing (i.e. steam, hot water or organic acid sprays) are also used to reduce contamination on carcasses. Further processing of whole muscle meat or trimmings into ground or minced product will transfer any contaminating pathogens from the surface of the meat onto other surfaces or internally into the meat product. Good hygienic practices and good manufacturing practices should be employed. Beef processing equipment, including saws and knives, used throughout the slaughtering and processing environment can also play a role in the contamination of edible meat products (Duffy et al. 2014). Effective and frequent cleaning and decontamination of equipment is essential. Rapid chilling of adequately spaced carcasses will minimise growth of any contaminating pathogen on the surface of carcasses. Surface dehydration during chilling is an additional control measure. The lower temperature limit for growth of STEC is 7^{o}C. (FSANZ 2009b). Maintenance of appropriate temperature control throughout the subsequent post-slaughter supply chain minimises further growth of any contaminating pathogens. The competent authority should have the legal power to set and enforce regulatory meat hygiene requirements, and have final responsibility for verifying that regulatory meat hygiene requirements are met. The role and the level of training, knowledge and skills of the veterinary inspector and other personnel involved in meat hygiene activities should be defined by the competent authority. The competent authority should also verify that the establishment operator has adequate systems in place to trace and withdraw meat from the food chain (Codex 2013).
Surveillance information: Infection with STEC is a notifiable disease in all Australian states and territories, with a reported incidence rate in 2016 of 1.4 cases per 100,000 population (340 cases), which includes both foodborne and non-foodborne cases. This is a significant increase from the previous five year mean of 0.6 cases per 100,000 population per year (ranging from 0.4 – 0.8 cases per 100,000 population per year). The most common STEC serotype identified in Australia in 2011 was O157 (38% of cases), followed by O111 (17% of cases). There were seven cases of STEC-associated HUS reported in Australia in 2011; no deaths were reported (NNDSS 2017; OzFoodNet 2015). **Illness associated with consumption of beef and beef products contaminated with STEC** A search of the scientific literature via EBSCO, US CDC Foodborne Outbreak Online Database and other publications from 2000 to June 2017 identified there have been > 130 international STEC outbreaks associated with consumption of beef and beef products from 2000, with >100 of these attributed to ground beef. Examples are listed below: *Ground beef* • USA (2013) – 24 *E. coli* O157:H7 cases linked to consumption of hamburgers cooked medium-rare. Eight cases required hospitalisation. Ground beef samples from the restaurant were positive for *E. coli* O157:H7 (Torso et al. 2015). • France (2011) – 18 *E. coli* O157:H7 (sorbitol-fermenting) cases linked to consumption of ground beef products. All 18 cases required hospitalisation and developed HUS. A particular producer of raw ground beef products was epidemiologically and microbiologically associated with the outbreak (King et al. 2014). • Japan (2011) – 86 *E. coli* O111:H8 cases epidemiologically linked to consumption of yukhoe, a raw beef dish similar to steak tartare (odds ratio of 19.6). Forty six cases required hospitalisation, with 34 cases developing HUS and five fatalities. Some patients were also positive for *E. coli* O157:H7 (Yahata et al. 2015).

General description

Whole muscle meat

- USA (2003) – ten *E. coli* O157:H7 cases linked to consumption of blade tenderized steaks. Three cases required hospitalisation and one case developed HUS. Blade tenderising and injection of marinate probably transferred O157:H7 from the surface to the interior of the steaks. *E. coli* O157:H7 from unopened product matched clinical cases (Swanson Laine et al. 2005).
- USA (between 2000 – 2015) – an additional eight *E. coli* O157 outbreaks linked to consumption of whole muscle cuts of beef, resulting in 97 cases, 35 hospitalisations and 1 fatality (CDC 2016).

Offal

- Japan (2005) – seven *E. coli* O157:H7 cases linked to consumption of beef offal. One case required hospitalisation. Restaurant customers were served raw offal and then broiled it themselves (Maruzumi et al. 2005).

Data on the prevalence of STEC in beef and beef products

A search of the scientific literature via EBSCO and other publications from 2000 to June 2017 identified that surveys of beef and beef products have isolated STEC in 0 to 15.6% of samples. Results from prevalence surveys are reported by the sample type (carcass, whole muscle meat, minced meat and trim, and offal) collected from abattoirs or meat processors. Retail surveys were excluded.

Carcass – prevalence of STEC ranged from 0 to 15.7% of samples, with an overall prevalence of 2.5% (95% CI 1.0% – 6.2%) determined using a random effects meta-analysis of seven surveys (surveys included product from Australia, Poland, Republic of Ireland, Serbia, Spain and/or USA). Examples are listed below:

- Spain (2009 – 2010) – *E. coli* O157:H7 was detected in 15.7% of dressed cattle carcass samples (n=300) collected from the slaughterhouse (Ramoneda et al. 2013).
- Australia (2004) – *E. coli* O157:H7 was detected in 0.1% of dressed beef carcass samples (n=1155) collected from the abattoir (Phillips et al. 2006).
- USA (2002 – 2003) – non-O157 STEC was detected on 5.8% of beef carcass samples (n=86) collected from the slaughterhouse (Cobbold et al. 2008).

Whole muscle meat – STEC was not detected in two Australian surveys of whole muscle meat (Phillips et al. 2006; Phillips et al. 2012), with an overall prevalence of 0% (95% CI 0.0% – 0.3%) determined using a random effects meta-analysis.

Minced meat and trim – prevalence of STEC ranged from 0 to 30% of samples, with an overall prevalence of 2.8% (95% CI 1.0% – 7.7%) determined using a random effects meta-analysis of ten surveys (surveys included product from Australia, Canada, France, Italy, New Zealand, Serbia, Uruguay and/or USA). Examples are listed below:

- Australia (2008 – 2009) – *E. coli* O157:H7 was detected on 1.7% of manufactured beef for grinding (n=4500) collected at the processing facility (Kiermeier et al. 2011).
- USA (2005 – 2008) – STEC was detected on 5.5% of ground beef samples (n=16160) and 15% of beef trim samples (n=892029) collected at meat processing facilities. In particular, *E. coli* O157:H7 was detected on 0.25% of ground beef samples (n=16160) and 0.82% of beef trim samples (n=892029) (Hill et al. 2011).
- USA (2005) – non-O157 STEC was detected on 30% (n=220), 9.7% (n=223) and 28% (n=256) of boneless beef trim imported from Australia, New Zealand and Uruguay, respectively, and sampled at the US border. Non- O157 STEC was detected on 30% of domestic boneless beef trim (n=487) sampled at production facilities (Bosilevac et al. 2007).

Offal – no surveys were identified in the literature search.

Standards or guidelines

- Division 2 of Standard 4.2.3 in the Australia New Zealand Food Standards Code requires primary producers of meat to control inputs, waste disposal and traceability.
- Australian Standard for the hygienic production and transportation of meat and meat products for human consumption (*AS 4696-2002)* sets out the outcomes required for the receival and slaughter of animals, the dressing of carcasses, the processing, packaging, handling and storage of meat or meat products; with process controls requiring a HACCP based system. The Standard also contains rules for the construction of premises and transportation of meat and meat products (Standards Australia 2002).
- Codex Code of Hygienic Practice for Meat *CAC/RCP 58-2005* covers hygiene provisions for raw meat, meat preparations and manufactured meat from the time of live animal production up to the point of retail sale (Codex 2013).

Standards or guidelines
• End product testing for indicator organisms (e.g. generic *E. coli*) can be used to verify process control for fresh chilled and frozen meat. However, these are poor indicators of the prevalence or concentration of enteric pathogens in fresh meat. For countries where *E. coli* O157:H7 is a pathogen of concern in ground beef (e.g. USA), beef trimmings used in ground beef are tested for *E. coli* O157:H7 (Codex 2013; ICMSF 2011).

Management approaches used by overseas countries

- Under the European Commission (EC) regulation 178/2002 food imported into the EU must comply with the relevant EU food law or where specific agreement exists between EU and the exporting country. Regulation 852/2004 covers hygiene of food at all stages of the production process from primary production to the final consumer, with Annex I covering activities connected with primary production. Regulation 853/2004 lays down specific hygiene rules for food of animal origin for food business operators, with Section I of Annex III covering primary processing of domestic ungulates (including bovine species).
- EC regulation 1441/2007 (European Commission 2007) specifies an *E. coli* limit for:
  - minced meat (n=5, c=2, m=50 cfu/g, M=500 cfu/g)
  - mechanically separated meat (n=5, c=2, m=50 cfu/g, M=500 cfu/g)
  - meat preparations (n=5, c=2, m=500 cfu/g, M=5000 cfu/g).
- Under the Canadian *Meat Inspection Regulations 1990* (Canadian Ministry of Justice 2014), a meat product can only be imported if the meat product was manufactured in an establishment that was operating under a HACCP principles based system determined to be equivalent to the Canadian Food Safety Enhancement Program. Domestic and imported raw ground beef or veal and imported beef trimmings and chunk intended for ground beef are monitored for generic *E. coli* as a marker of contamination and for *E. coli* O157:H7/NM. Product positive for *E. coli* O157:H7 and/or *E. coli* O157:NM is classed as adulterated (unsatisfactory)(Canadian Ministry of Justice 2014; CFIA 2017).
- In the US, imported meat is subject to the requirements of the Federal Meat Inspection Act (USDA 2016) which sets out that carcasses and meat can only be imported if they are subject to the inspection, sanitary, quality, species verification, residue standards, and humane methods of slaughter applied to products produced in the United States. The US Department of Agriculture Food Safety and Inspection Service (FSIS) are responsible for imported food and carry out audits of foreign inspection systems and re-inspect meat at the port-of-entry to ensure that foreign countries have maintained equivalent inspection systems (FSIS 2014).Carcasses and meat are not permitted to be imported into the US if they are adulterated. The US considers all non-intact raw beef and intact raw beef intended to be processed into non-intact products that are contaminated with *E. coli* O157:H7, or one of six non-O157 STECs (O26, O45, O145, O103, O111, and O121), to be adulterated (USDA 2016; FSIS 2016).
- In New Zealand imported bovine meat is not a food of high (or increased) regulatory interest for the hazard STEC (NZ MPI 2016).

This risk statement was compiled in: September 2017

References

Adam K, Brulisauer F (2010) The application of food safety interventions in primary production of beef and lamb: A review. International Journal of Food Microbiology 141(Suppl):S43-S52

Australian Bureau of Statistics (2011) National Nutrition and Physical Activity survey, 2011-2012, Basic CURF, CD-ROM. Findings based on ABS Curf data.

Bosilevac JM, Guerini MN, Brichta-Harhay DM, Arthur TM, Koohmaraie M (2007) Microbiological characterization of imported and domestic boneless beef trim used for ground beef. Journal of Food Protection 70(2):440–449

Canadian Ministry of Justice (2014) Meat Inspection Regulations, 1990 (SOR/90-288). http://laws-lois.justice.gc.ca/PDF/SOR-90-288.pdf. Accessed 20 July 2017

CDC (2016) Foodborne outbreak online database (FOOD): Centers for Disease Control and Prevention, Atlanta. https://wwwn.cdc.gov/foodborneoutbreaks/. Accessed 5 July 2017

CFIA (2017) Meat hygiene manual of procedures: Canadian Food Inspection Agency, Ottawa. http://www.inspection.gc.ca/food/meat-and-poultry-products/manual-of-procedures/eng/1300125426052/1300125482318. Accessed 20 July 2017

Cobbold RN, Davis MA, Rice DH, Szymanski M, Tarr PI, Besser TE, Hancock DD (2008) Associations between bovine, human, and raw milk, and beef isolates of non-O157 Shiga toxigenic Escherichia coli within a restricted geographic area of the United States. Journal of Food Protection 71(5):1023–1027

Codex (2013) Code of hygienic practice for meat (CAC/RCP 58-2005). Codex Alimentarius, Rome. http://www.fao.org/fao-who-codexalimentarius/standards/list-of-standards/en/. Accessed 22 June 2017

Duffy G, Burgess CM, Bolton DJ (2014) A review of factors that affect transmission and survival of verocytotoxigenic Escherichia coli in the European farm to fork beef chain. Meat Science 97(3):375–383

ECDC/EFSA (2011) Shiga toxin/verotoxin-producing *Escherichia coli* in humans, food and animals in the EU/EEA, with special reference to the German outbreak strain STEC O104. European Centre for Disease Prevention and Control, Stockholm. http://onlinelibrary.wiley.com/doi/10.2903/sp.efsa.2011.EN-166/abstract. Accessed 11 April 2014

European Commission (2007) Commission Regulation (EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs. Official Journal of the European Union 7.12.2007:L322 12–L322 29

FDA (2012) Bad bug book: Foodborne pathogenic microorganisms and natural toxins handbook, 2nd ed. US Food and Drug Administration, Silver Spring. http://www.fda.gov/food/foodborneillnesscontaminants/causesofillnessbadbugbook/default.htm. Accessed 23 July 2015

FSANZ (2009a) Assessment of microbiological hazards associated with the four main meat species. Food Standards Australia New Zealand, Canberra. http://www.foodstandards.gov.au/code/proposals/documents/P1005%20PPPS%20for%20Meat%20_%20Meat%20Products%201AR%20SD1.pdf. Accessed 24 July 2017

FSANZ (2009b) Proposal P1005 - Primary production & processing standards for meat and meat products. SD3: Controls to manage identified hazards. Food Standards Australia New Zealand, Canberra. http://www.foodstandards.gov.au/code/proposals/documents/P1005%20PPPS%20for%20Meat%20_%20Meat%20Products%201AR%20SD3.pdf. Accessed 24 July 2017

FSANZ (2013) Agents of foodborne illness, 2nd ed. Food Standards Australia New Zealand, Canberra. http://www.foodstandards.gov.au/publications/Documents/FSANZ_FoodborneIllness_2013_WEB.pdf. Accessed 4 September 2013

FSIS (2014) FSIS Import Procedures for meat, poultry & egg products. Food Safety and Inspection Service, United States Department of Agriculture, Washington D.C. https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/production-and-inspection/fsis-import-procedures-for-meat-poultry-and-egg-products/fsis-import-procedures. Accessed 24 August 2017

FSIS (2016) Raw beef product sampling. Food Safety and Inspection Service, United States Department of Agriculture, Washington D.C. https://www.fsis.usda.gov/wps/wcm/connect/50c9fb74-c0db-48cd-a682-b399ed6b70c0/29_IM_Raw_Beef_Prod_Sampling.pdf?MOD=AJPERES. Accessed 20 July 2017

Gyles CL (2007) Shiga toxin-producing *Escherichia coli*: An overview. Journal of Animal Science 85(E Suppl) E45-E62

Hill WE, Suhalim R, Richter HC, Smith CR, Buschow AW, Samadpour M (2011) Polymerase chain reaction screening for Salmonella and enterohemorrhagic Escherichia coli on beef products in processing establishments. Foodborne Pathogens and Disease 8(9):1045–1053

ICMSF (1996) Intestinally pathogenic Escherichia coli. In: ICMSF (ed) Microorganisms in food 5: Microbiological specifications of food pathogens, Ch 7. Blackie Academic and Professional, London, pp 126–140

ICMSF (2005) Meat and meat products. In: ICMSF (ed) Microorganisms in foods 6: Microbial ecology of food commoditites, 2nd ed, Ch 1. Kluwer Academic/Plenum Publishers, New York, pp 1–106

ICMSF (2011) Meat products. In: ICMSF (ed) Microorganisms in food 8: Use of data and assessing process control and product acceptance, Ch 8. Springer, New York, pp 75–93

Kiermeier A, Mellor G, Barlow R, Jenson I (2011) Assumptions of acceptance sampling and the implications for lot contamination: Escherichia coli O157 in lots of Australian manufacturing beef. Journal of Food Protection 74(4):539–544

King LA, Loukiadis E, Mariani-Kurkdjian P, Haeghebaert S, Weill F-X, Baliere C, Ganet S, Gouali M, Vaillant V, Pihier N, Callon H, Novo R, Gaillot O, Thevenot-Sergentet D, Bingen E, Chaud P, Valk H (2014) Foodborne transmission of sorbitol-fermenting Escherichia coli O157:[H7] via ground beef: An outbreak in northern France, 2011. Clinical Microbiology & Infection 20(12):O1136-O1144

Maruzumi M, Morita M, Matsuoka Y, Uekawa A, Nakamura T, Fuji K (2005) Mass food poisoning caused by beef offal contaminated by Escherichia coli O157. Japanese Journal of Infectious Diseases 58(6):397

Meng J, Schroeder CM (2007) *Escherichia coli*. In: Simjee S (ed) Foodborne diseases, Ch 1. Humana Press, Totowa, pp 1–25

Meng J, LeJeune JT, Zhao T, Doyle MP (2013) Enterohemorrhagic *Escherichia coli*. In: Doyle M, Beuchat L (eds) Food microbiology: Fundamentals and frontiers, 4th ed, Ch 12. ASM Press, Washington D.C., pp 287–309

NNDSS (2017) Notifications for all disease by State & Territory and year. National Notifiable Disease Surveillance System, Department of Health and Ageing, Canberra. http://www9.health.gov.au/cda/source/rpt_2_sel.cfm. Accessed 5 July 2017

NZ MPI (2016) Food notice - Importing food. New Zealand Ministry for Primary Industries, Wellington

OzFoodNet (2015) Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: Annual report of the OzFoodNet Network, 2011. Communicable Diseases Intelligence 39(2):E236-E264

Phillips D, Jordan D, Morris S, Jenson I, Sumner J (2006) A national survey of the microbiological quality of beef carcasses and frozen boneless beef in Australia. Journal of Food Protection 69(5):1113–1117

Phillips D, Bridger K, Jenson I, Sumner J (2012) An Australian national survey of the microbiological quality of frozen boneless beef and beef primal cuts. Journal of Food Protection 75(10):1862–1866

Ramoneda M, Foncuberta M, Simón M, Sabaté S, Ferrer MD, Herrera S, Landa B, Musté N, Martí R, Trabado V, Carbonell O, Vila M, Espelt M, Ramírez B, Durán J (2013) Prevalence of verotoxigenic Escherichia coli O157 (VTEC O157) and compliance with microbiological safety standards in bovine carcasses from an industrial beef slaughter plant. Letters in Applied Microbiology 56(6):408–413

Standards Australia (2002) The hygienic production and transportation of meat and meat products for human consumption (AS 4696-2002) Standards Australia International, Sydney

Swanson Laine E, Scheftel JM, Boxrud DJ, Vought KJ, Danila RN, Elfering KM, Smith KE (2005) Outbreak of Escherichia coli O157:H7 Infections Associated with Nonintact Blade-Tenderized Frozen Steaks Sold by Door-to-Door Vendors. Journal of Food Protection 68(6):1198–1202

Tamplin ML, Paoli G, Marmer BS, Phillips J (2005) Models of the behavior of Escherichia coli O157:H7 in raw sterile ground beef stored at 5 to 46 degrees C. International Journal of Food Microbiology 100(1-3):335–344

Torso L, Voorhees RE, Forest SA, Gordon AZ, Silvestri SA, Kissler B, Schlackman J, Sandt CH, Toma P, Bachert J, Mertz KJ, Harrison L (2015) Escherichia coli O157:H7 outbreak associated with restaurant beef grinding. Journal of Food Protection 78(7):1272–1279

USDA (2016) Federal Meat Inspection Act. United States Department of Agriculture, Washington D.C. https://www.fsis.usda.gov/wps/portal/fsis/topics/rulemaking/federal-meat-inspection-act. Accessed 20 July 2017

Yahata Y, Misaki T, Ishida Y, Nagira M, Watahiki M, Isobe J, Terajima J, Iyoda S, Mitobe J, Ohnishi M, Sata T, Taniguchi K, Tada Y, Okabe N (2015) Epidemiological analysis of a large enterohaemorrhagic Escherichia coli O111 outbreak in Japan associated with haemolytic uraemic syndrome and acute encephalopathy. Epidemiology and Infection 143(13):2721–2732