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EVIDENCE BRIEF

Can You Prepare Raw Meat Dishes Safely?

August 2018

Key Messages

- While raw meat dishes are popular, raw meat can be contaminated with pathogens.
- Eating raw meat products can cause foodborne infections.
- Jurisdictions have different requirements related to meat intended for raw consumption.
- Interventions from slaughter to preparation for retail practices for consumption can reduce, but not eliminate, the risk of infections from raw meat products.
- Warnings about the risks associated with raw meat consumption can help inform decision-making by consumers.

Issue and Research Question

The 1993 Jack In The Box *E. coli* outbreak in the United States, which resulted in 700 illnesses and four deaths, highlights the importance of cooking raw meat to appropriate internal temperatures.[1] Twenty years later, raw meat dishes, such as beef kibbeh, steak tartare and carpaccio are offered by restaurants in Ontario and across Canada. Despite the risks associated with its consumption, many people consume raw meat dishes.[2] In response to a request in 2015, Public Health Ontario reviewed regulatory practices as well as the current evidence available on food preparation practices or methods, excluding heat treatment, which may reduce pathogenic load in the ready-to-eat raw meat dishes. Assessing the effectiveness of each identified food preparation practice was beyond the scope of this review.

Methods

To identify relevant scientific literature, Public Health Ontario (PHO)'s Library Services performed a search using 1) MEDLINE, 2) Food Science Source, and 3) Scopus databases. The search was limited to literature published in English from January 1, 1995 to July 10, 2015. To update this search, a rapid Google Scholar search of this topic was done in 2018, which yielded three additional papers. The search strategy included terms such as: beef, veal, lamb, mutton, pork, raw or uncooked food, meat or meat products, cig kofte, kibbeh nayeh, gyu tataki, yukhoe, carpaccio, ossenworst, bacterial load, colony count, microbial, foodborne illness/disease, food contamination, food industry, food microbiology, food preservatives, food safety, food storage, garlic, citric acid, lemon, lime, temperature, yogurt, ceviche, chop, microbial quality, pathogen, *Salmonella, E. coli, Listeria*, hepatitis E virus and *Trichinella*. A total of 1257 articles were identified, and 1148 records were left after duplicates removed. Titles and abstracts were screened for relevance by two reviewers. Articles which only pertained to poultry and/or ground poultry were excluded. Additional information was identified through cited reference searching of full-text articles.

For evidence of outbreaks associated with raw meat dishes, a search was conducted through the Public Health Agency of Canada's "Publically Available International Foodborne Outbreak Database" (PAIFOD), from January 1, 2010 to February 21, 2018, on documented outbreaks associated with raw meat dishes.

Regulatory approaches used to reduce the risk associated with serving raw meat dishes were identified by Public Health Ontario's Library Services through a search using the Canadian Legal Information Institute (CanLII) website and Google in 2015. The search was limited to reports published in English. This was updated for Ontario in early 2018 due to regulatory changes that will take effect July 2018.

The search strategy for CanLII included terms such as "food premises, food handling, food code, food regulation, food temperature, food establishment and food safety." The Google search included:

- meat "eaten raw" OR "consumed raw" OR "served raw," law OR legislation OR regulation OR ban,
- minimum-internal-temperature, meat OR beef OR pork and

- meat "eaten raw" OR "consumed raw" OR "served raw", restaurant OR food-premises OR food-services.

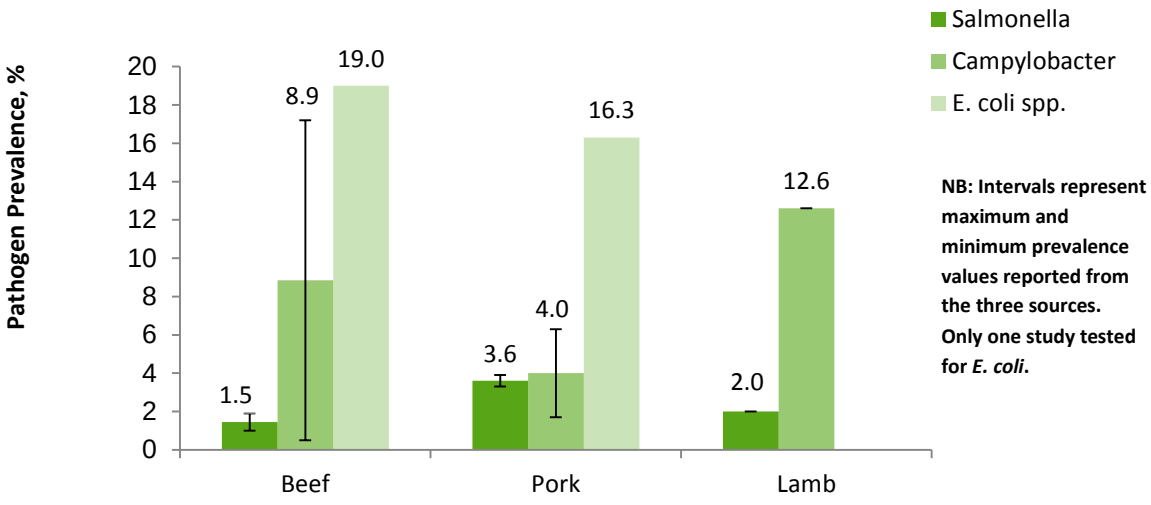
A total of 70 records are included in this report.

Main Findings

Microbial prevalence

Raw meat can harbour foodborne pathogens.[3–7] The type of pathogen and load vary depending on practices used at processing plants, farms, abattoirs, and restaurants, as well as on animal species and cuts of meat.[8,9] Figure 1 demonstrates the mean prevalence of pathogens in beef, pork and lamb from studies that sampled retail raw meat in the US (two studies) and UK (one study) between 1999 to 2010. Zhao et al.[3] tested for indicator *E. coli* in retail raw meats sampled in the greater Washington DC area, Vipham et al.[6] tested for *Salmonella* and *Campylobacter* spp in raw meats sampled across the US, and Little et al.[4] assessed prevalence of *Salmonella* and *Campylobacter* spp in raw meats sampled in UK markets.

Figure 1: Prevalence of Campylobacter, Salmonella, and E. coli spp. in different types of raw retail meat in US and UK (1999-2010)[3,4,6]



The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) conducts microbial baseline studies of products produced and sold in Ontario. In a 2003 study of raw beef, 1566 samples were analyzed for indicator organisms: aerobic colony count (ACC), total coliform count (TCC), generic *E. coli* count (ECC), as well as *Campylobacter jejuni/coli*, *Listeria monocytogenes, Salmonella* spp. and verotoxigenic *E. coli* (VTEC). A second study also in 2003 looked for surface contamination of 1557 pork carcasses. They found:[10,11]

- *L. monocytogenes* was most prevalent in beef (9.9%), followed by *Salmonella* (1.6%), *C. jejuni/coli* (1.5%), and VTEC (0.3%). Lower volume beef processing plants have a lower prevalence of *Salmonella* spp. and *C. jejuni/coli.*

- *C. jejuni/coli* (26.7%) was most prevalent in pork, followed by *L. monocytogenes* (10.7%), *Salmonella* spp. (4.8%) and VTEC (2.1%). Pork processing plants with lower volumes had a lower prevalence of *L. monocytogenes* and *Salmonella* spp. compared to higher volume plants.

- All beef and pork samples tested were positive for ACC. Pork had higher prevelance of TCC and ECC than beef (pork: 61.3% TCC and 39.5% ECC vs beef: 27.8% TCC and 18.6% ECC).

Factors associated with lower pathogen contamination in beef from the OMAFRA study included:

- Younger animals (*Salmonella* and *Campylobacter*).

- Bed-dressed compared to rail-dressed (*L. monocytogenes*).

- Fed beef versus culled beef[a] (*Salmonella* and *Campylobacter*)

- Manual compared to mechanical de-hiding (*L. monocytogenes*).

Shrouding beef carcasses had no impact on microbial contamination.

Foodborne illness outbreaks associated with raw meat dishes

- Raw meat dishes have been associated with foodborne illness outbreaks.[2,12–21]

- Between January, 1, 2010 and February 21, 2018, 63 foodborne outbreaks associated with raw or unprocessed beef (36) , pork (21), lamb (1) and other meats (5) were documented in the PAIFOD.[12]

- *Salmonella* species were most commonly associated with outbreaks involving raw/unprocessed beef (22/37), followed by *E. coli* (8/37).[12]

- *Salmonella* species were also most commonly associated with outbreaks involving raw/unprocessed pork (12/21), followed by *Trichinella* (2/17) and *Campylobacter* spp (2/17).[12]

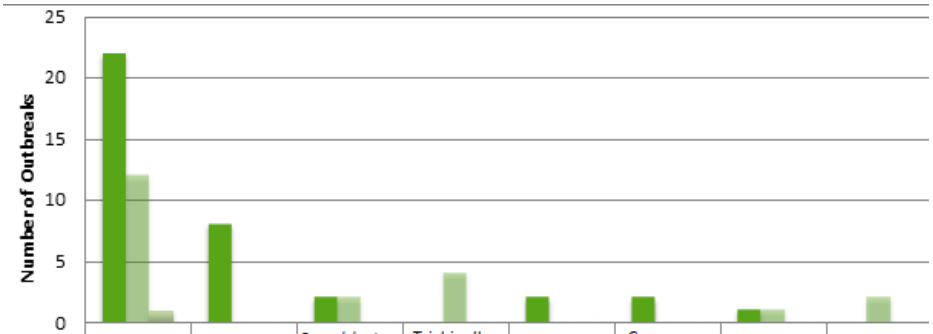
- In 2013, an *E. coli* O157:H7 outbreak in Canada, resulting in seven cases of illness from three provinces, was associated with consumption of raw beef and veal tartares.[12,18]

- Raw meat dishes have also been associated with outbreaks of hepatitis A virus, *Trichinella spiralis* and *Toxoplasmosis gondii* infections globally.[21–24]

[a]Culled beef is from cows and bulls; fed beef is from steers and heifers that are raised in feedlot (Personal communication: 2015, Email from Janet Alsop, Ontario Ministry of Agriculture and Rural Affairs)

- Figure 2 summarizes reported foodborne outbreaks associated with consumption of raw beef, lamb and pork identified by our review.

Figure 2: Pathogens associated with outbreaks attributed to raw beef and pork, published January 2010 to February 2018[2,12–21]



	Salmonella spp.	*E. coli* spp.	*Campylobacter* spp.	*Trichinella* spp.	*Toxocara*	*C. perfringens*	Norovirus	Hepatitis E
Beef	22	8	2	0	2	2	1	0
Pork	12	0	2	4	0	0	1	2
Lamb	1	0	0	0	0	0	0	0

Preventive measures to reduce microbial contamination in raw meat

Reducing microbial load in raw products is an ongoing area of research and development. Animal hides have been identified as the primary source of *E. coli* in cattle resulting in surface contamination of beef carcasses. During slaughtering, dressing and processing of meat, *E. coli* O157 and other bacterial pathogens present on the hide or in the intestines of the animal can be transferred to the surface of the meat. Generally, this contamination is limited to the surface of intact cuts of meat.[25,26]

Various methods, from farm to fork, have been developed or are being researched to reduce pathogen load in food, including raw meat. A recent rapid systematic review and meta-analysis[27] concluded that some interventions at slaughter and processing that reduced *Salmonella* under controlled laboratory conditions (pre-chill hot water washes and steam pasteurization) were not effective in the field. The review also found that the efficacy of organic acid washing may vary depending on process parameters and the initial bacterial load. The review suggested that multiple interventions may improve reduction of *Salmonella.*

Many recipes for raw meat dishes require addition of other ingredients such as garlic, lemon juice and yoghurt. The addition of lemon juice,[61,62] garlic[63] and yoghurt[64] to raw meat have been shown to assist in reducing microbial load, but do not eliminate the risk of foodborne pathogens from consuming of raw meat dishes. Similarly sear-and-shave procedures have the potential to reduce the microbiological load on intact pieces of meat.[59,60] In food establishments, implementation of Hazard Analysis and Critical Control Point (HACCP) systems and improved hand hygiene can reduce additional contamination and pathogen growth. Table 1 provides examples of interventions to reduce pathogen load at different stages of meat processing. Although these measures provide barriers against pathogen contamination and growth, foodborne illness risk cannot be eliminated for ready-to-eat raw meat dishes.

Table 1: Stages of meat processing and examples of interventions to reduce pathogen load [25,53–64]

Meat processing stage	Interventions to reduce pathogen load (examples)
Slaughtering (including dressing[b] and fabrication[c])	Hide: • Chemical dehairing • Water wash followed by an antibiotic treatment • Washing hides with ozonated and/or electrolyzed oxidizing waters Carcass: • Steam vacuuming • Organic acids and hot water wash • Low-dose, low-penetrating radiation • Test-and-hold process (holding the product while microbiological testing is performed) Trim: • Acidified sodium chlorite treatment • Combination treatment • Test-and-hold process
Post slaughter and retail	• Gamma radiation • High pressure processing (HPP)[d] • Sear and shave[e]

[b] In respect of the carcass of a slaughtered food animal, other than a pig or bird, it is a process of removal of the skin, the head, developed mammary gland and feet at carpal and tarsal joints; to eviscerate, and to split (except in the case of a sheep, goat, deer or rabbit).[69]
[c] Creating various cuts from the carcass to produce particular types of product.[70]
[d] An emerging technology aimed to reduce microbial load. It applies pressure to packaged food, that is submerged in a liquid within enclosed vessel, interrupting the cellular function of microorganisms and causing cells to die.[54] Several studies have demonstrated effectiveness of HPP for inactivation of *L. monocytogenes, S.* Enteritidis *and E. coli* 0157 in inoculated beef.[56,57]
[e] High temperature treatment of intact meat, followed by shaving off the cooked portion of the meat using clean and sanitized utensils.[59]

Meat processing stage	Interventions to reduce pathogen load (examples)
	• Addition of other ingredients such as garlic, lemon juice and yogurt • Use of whole muscle meat/intact beef • Labelling and consumer education • Implementation of HACCP system

Jurisdictional Scan

Regulatory approaches and guidance for raw meat dishes vary across Canada, the United States (US), the United Kingdom (UK) and Australia. Regulations and/or guidelines from ten Canadian provinces and three territories, as well as national guidelines for Canada, the US, Australia and the UK were reviewed.

National guidance documents for all countries reviewed have a permissive approach to raw meat dishes, with conditions related to vulnerable populations, consumer awareness and/or other post-slaughter or retail risk reduction measures.[28–31]

In Canada, provincial and territorial regulation and/or guidelines may require all meat to be cooked (n=1),[32] allow raw meat to be served with risk reduction measures (n=1)[33,34] or have a general requirement that served food be safe (n=10).[35–42] Ontario's new food safety regulation, effective July 2018, does not prescribe cooking temperatures for meat.[43]

In the US, all states identified in the jurisdictional scan (n=8; South Carolina, Minnesota, Wisconsin, Alaska, Michigan, New York, Southern Nevada and Ohio) use permissive approaches, similar to the US Federal Food Code, commonly requiring raw meat dishes to be rendered safe to eat and warnings be provided to consumers.[29,44–52] UK and Australia provide national level guidance.[30,31] Table 2 summarizes this information.

Table 2: Summary of jurisdictional scan of regulation, guidelines and/or recommendations for raw meat dishes[28-52,65–68]

Region	General requirement that served food to be safe with no mention of specific cooking requirements	Serving raw meat dishes allowed with conditions	All raw meat must be cooked prior to serving
Canada	British Columbia, Saskatchewan, Manitoba, Quebec, Nova Scotia, New Brunswick, Newfoundland, Yukon Territories, Northwest Territories, Nunavut, Ontario (starting July 2018)	Federal, Alberta	Prince Edward Island
United States		Federal (non-binding), Minnesota, Wisconsin, Ohio, Michigan, New York State, New York City, South Carolina, Southern Nevada	
International		United Kingdom, Australia	

Discussion and Conclusions

Raw meat can harbour foodborne pathogens and consumption of contaminated raw meat has been associated with foodborne illnesses and outbreaks. The pathogen type and load can vary depending on several factors: the animal species (beef, lamb or pork), the cut of meat (sirloin vs. rib), and the processes and practices used in farms, abattoirs, processing plants and restaurants.

Interventions exist throughout food production to reduce pathogen loads in meat. At the slaughtering, dressing and fabrication stages, interventions such as chemical dehairing of hides, steam vacuuming of carcasses, and acidified sodium chlorite treatment of trim can reduce pathogen load.[25] Gamma radiation and high pressure processing are additional technologies that may be applied prior to retail.[53–57] When food is being prepared, searing and shaving may reduce risk as intact whole meat is considered sterile

inside.[58–60] Ingredients such as lemon, garlic and yogurt during preparation may also reduce pathogen load.[61–64] However, even with these measures, the risk of foodborne illnesses associated with consumption of raw meat dishes cannot be eliminated.[5]

Consumer education, specifically for susceptible populations (elderly, children, pregnant women and immune-compromised individuals), plays an important role in informed decision-making by consumers and may reduce the risk of foodborne illnesses associated with raw meat dishes.[2,17,18]

Canada, the UK, US, and Australia provide regulations and/or guidance at the national level to mitigate the risks associated with raw meat dishes. With respect to regulations in Canada, most jurisdictions have general requirements for food to be rendered safe while Prince Edward Island has cooking requirements for meat that preclude raw meat dishes from being served.

Incorporating interventions, consumer education, regulations and guidelines will assist in preparing safer raw meat dishes but it will not entirely eliminate the risk of foodborne illness.

Implications for Practice

Consuming raw meat dishes can result in foodborne infections. For meat intended to be consumed raw, production practices as well as preparation methods may reduce but not eliminate the risk of disease. Warnings about the risks associated with raw meat consumption can help inform decision-making by consumers.

National level guidance exists for Canada, US, UK and Australia. In Canada, provincial regulations vary by jurisdiction.

Specifications and Limitations of Evidence Briefs

The purpose of this Evidence Brief is to investigate a research question in a timely manner to help inform decision making. The Evidence Brief presents key findings, based on a systematic search of the best available evidence obtained in the 2015 literature review and a subsequent 2018 rapid Google Scholar search, as well as systematic screening and extraction of data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this brief whether individual studies would alter the conclusions drawn from the document.

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