

**Table 3.1. Microbial pathogens detected in spices, 1985-2012: Review of the scientific literature and the CDC PulseNet and FDA FACTS databases<sup>a</sup>**

Microbial Pathogens	Spice <sup>b</sup>	Reference
<i>Salmonella</i> spp.	ajowan, alfalfa seeds, allspice, anise seed, asafetida, basil, bay, black pepper, capsicum (hot and sweet), cardamom, cayenne, celery seed, cinnamon, coriander, cumin, curry leaf, fennel, fenugreek leaves and seeds, fingerroot, garlic, ginger, nigella, London rocket, mace, mint, mustard seed, nutmeg, oregano, parsley, sage, thyme, sumac, sesame seeds, turmeric, white pepper, spice mixes/seasonings (e.g., curry, five spice, garam masala)	Arias <i>et al.</i> , 1997; Banerjee and Sarkar, 2003; CDC-PulseNet; DOH/Victoria/AU, 2010; FSAI, 2004; Gustavsen and Breen, 1984; FDA-FACTS <sup>d</sup> ; Hampikyan <i>et al.</i> , 2009; Hara-Kudo <i>et al.</i> , 2006; Higa, 2011; Kaul and Taneja, 1989; Kneifel and Berger 1994; Koch <i>et al.</i> 2005; Moreira <i>et al.</i> 2009; Sagoo <i>et al.</i> 2009; Satchell <i>et al.</i> 1989; Singh <i>et al.</i> 2007; Shamsuddeen, 2009; Stewart <i>et al.</i> 2001; Vij <i>et al.</i> 2006
<i>Bacillus</i> spp. (including <i>B. cereus</i> )	ajowan, alligator pepper, allspice, asafetida, basil, bay leaf, black pepper, capsicum (hot and sweet), caraway, cardamom, celery seed, chervil, chives, cinnamon, cumin, cloves, coriander, cumin, dill, fennel seeds, fenugreek, fennel, garlic, ginger, nutmeg, mace, marjoram, mustard seed, nutmeg, onion, oregano, unspecified pepper, poppy seed, rosemary, saffron, thyme, turmeric, white pepper, spice mixes/seasonings	Antai, 1988; DOH/Victoria/AU, 2010; Banerjee and Sarkar, 2003; Brown and Jiang, 2008; Cosano <i>et al.</i> , 2009; FSAI, 2004; Garcia <i>et al.</i> , 2001; Hampikyan <i>et al.</i> , 2009; Kahraman and Ozmen, 2009; Kneifel and Berger, 1994; Kovács-Domján 1988; Little <i>et al.</i> , 2003; Moreira <i>et al.</i> , 2009; Pafumi, 1986; Sagoo <i>et al.</i> , 2009; Witkowska <i>et al.</i> , 2011
<i>Clostridium perfringens</i>	ajowan, anise seed, bay leaf, black cumin, black pepper, capsicum (hot and sweet), caraway, chives, cinnamon, clove, coriander, cumin, ginger, fenugreek, garlic, ginger, mace, mustard seed, nutmeg, onion, oregano, parsley, saffron, white pepper	Aguilera <i>et al.</i> , 2005; Banerjee and Sarkar, 2003; Cosano <i>et al.</i> , 2009; Pafumi, 1986; Rodriguez-Romo, 1998; Sagoo <i>et al.</i> , 2009; Shamsuddeen, 2009
<i>Cronobacter</i> spp.	anise seed, rosemary	Ahene <i>et al.</i> , 2011; Baumgartner <i>et al.</i> , 2009; Iverson and Forsythe (2004); Jaradat <i>et al.</i> , 2009; Turcovský <i>et al.</i> , 2011
<i>Shigella</i>	ajowan, bay leaf	Banerjee and Sarkar, 2003
<i>Staphylococcus aureus</i>	asafoetida, black pepper, capsicum, cardamom, cinnamon, garlic, ginger, white pepper.	Banerjee and Sarkar, 2003; Hampikyan <i>et al.</i> , 2009; Moreira <i>et al.</i> , 2009; Kahraman and Ozmen, 2009; Shamsuddeen, 2009

<sup>a</sup> Literature reviewed period: January 1, 1985 through July 1, 2012. The CDC PulseNet database was reviewed between Sept. 2001 and February 2010 for pepper and pepper-type spices and reviewed between January 2001 and June 2010 for non-pepper spices uploaded to the CDC PulseNet database, supplemented by the FDA *Salmonella* isolate database reviewed during the period 2006-2010 for spices not captured in the CDC PulseNet database review for the period 2006-2010.

<sup>b</sup> Different forms of the same spice or spice mixture are generally not distinguished, e.g., dried coriander leaves and seeds, or masala spice mix for chicken and masala mix for beef. Capsicum may include both hot and sweet varieties such as cayenne, paprika, chili powder, and other dried whole or ground spices made from capsicum peppers. A single common name was selected for a spice in this table, which may differ from the name in the original reference, e.g., ajowan instead of bishop's weed or omum.

<sup>c</sup> *Salmonella* isolates from (a) pepper and pepper-type spices (entries including the words "pepper", "chili", or "cayenne" and, for the capsicums, clearly indicated as a dry product) uploaded to the CDC PulseNet database between Sept. 2001 and February 2010 and (b) all other spices uploaded to the CDC PulseNet database between January 2001 and June 2010.

<sup>d</sup> *Salmonella* isolates from spices sampled by FDA during 2006-2010, reported in the FDA FACTS database.

As discussed in Chapter 2, only *Salmonella* and *Bacillus* spp. have been definitively linked to human illness outbreaks resulting from consumption of contaminated spices. Furthermore, *Salmonella* contamination of spices has been the leading cause for spice-associated recalls in the United States (1970-2003: Vij *et al.*, 2006; 2008-2009: Ma, 2013) and the leading hazard reported for spices and seasonings in the Reportable Food Registry in first three annual reports (Sept. 8, 2009 - Sept 7, 2012) (FDA, 2013a; FDA, 2012a; FDA, 2012b). Therefore, as dictated by the scope of the risk profile, the remainder of the risk profile focuses on *Salmonella* contamination of spices and also addresses contamination by commonly occurring types of filth.