

## iMIS Food - Biological Hazards - Pathogenic Bacteria Table

Genus	Pathogenic Species	Morphology & Characteristics	Growth Conditions	Origin & Food Products	MID	Health Effects	Regulations (EU)	Prevention & Control	Inactivation
<i>Aeromonas</i>	<i>A. hydrophila</i> , <i>A. caviae</i> , <i>A. sobria</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Rod-shaped</li> <li>Motile</li> <li>Biofilm-former</li> </ul>	<b>T range:</b> Wide (grows well in the cold). <b>Optimum T:</b> 28-35°C. <b>pH range:</b> Wide (4.0-10.0).	<u>Origin:</u> Aquatic environments, soil. <u>Food products:</u> Fish, shellfish, fresh produce, meat.	High	<b>Gastroenteritis:</b> Diarrhoea, vomiting. Serious illness in vulnerable people. Onset: 12-48 hours.	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 2073/2005:</b> No specific criteria.</li> <li>• <b>Reg. (EC) 853-4/2004:</b> GHP.</li> </ul>	<ul style="list-style-type: none"> <li>• GHP (cleaning/disinfection, especially water contact surfaces).</li> <li>• Validated thermal processes (cooking/pasteurization).</li> <li>• Use of potable water.</li> <li>• Rapid chilling and cold chain maintenance.</li> </ul>	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Grows in refrigerated conditions; resistant to low pH.
<i>Bacillus</i>	<i>B. cereus</i>	<ul style="list-style-type: none"> <li>Gram+</li> <li>Large rod-shaped</li> <li><b>Spore-forming</b> (key feature)</li> <li>Strong biofilm-former</li> </ul>	<b>T range:</b> Wide (4-55°C). <b>Optimum T:</b> 30-40°C.	<u>Origin:</u> Ubiquitous in soil, dust. <u>Food products:</u> Rice, pasta, starchy foods, sauces, spices, dairy.	High (>10 <sup>5</sup> cells/g)	<u>Emetic:</u> Nausea, vomiting (toxin in food). <u>Diarrhoeal:</u> Cramps, diarrhoea (toxin in gut).	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 2073/2005:</b> No specific criteria.</li> <li>• <b>Reg. (EC) 853-4/2004:</b> GHP.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Critical: Rapid cooling</b> of cooked foods. Hot holding (&gt;60°C).</li> <li>• Thorough reheating.</li> <li>• GHP and sanitation.</li> </ul>	<u>Vegetative cells:</u> Heat-sensitive. <u>Spores:</u> <b>Extremely heat-resistant</b> (requires UHT or retorting). <u>Resistance:</u> Spores are resistant to drying, freezing.
<i>Brucella</i>	<i>B. melitensis</i> , <i>B. abortus</i> , <i>B. suis</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Coccobacillus</li> <li>Non-motile</li> </ul>	<b>Optimum T:</b> 37°C. <b>Grows best</b> near neutral pH.	<u>Origin:</u> Infected animals (cattle, sheep, goats). <u>Food products:</u> Unpasteurised milk and fresh dairy products.	Very low (<100 cells)	<b>Brucellosis:</b> Flu-like symptoms, undulating fever, chronic illness. Onset: Weeks to months.	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 853/2004:</b> GHP (milk must be from brucellosis-free herds).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Critical: Validated pasteurisation</b> of milk.</li> <li>• Sourcing milk exclusively from certified disease-free herds.</li> </ul>	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Survives chilling, freezing, and prolonged periods in unpasteurised products.

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<i>Campylobacter</i>	<i>C. jejuni</i> , <i>C. coli</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Slender, spiral rod</li> <li>Motile (corkscrew)</li> <li>Microaerophile</li> </ul>	<b>Optimum T:</b> 42°C (thermotolerant). <b>Sensitive</b> to high oxygen levels.	<u>Origin:</u> GI tract of warm-blooded animals, especially poultry. <u>Food products:</u> Raw/undercooked poultry, unpasteurised milk, cross-contaminated foods.	Low (<500 cfu)	<b>Campylobacteriosis:</b> Fever, abdominal pain, diarrhoea (often bloody). Sequelae: Guillain-Barré syndrome.	<b>• Reg. (EU) 2017/1495:</b> Process hygiene criterion for broiler carcasses. <b>• Reg. (EC) 2073/2005:</b> Requires monitoring.	<b>• Critical: Cross-contamination prevention</b> (separation of raw poultry). • Validated cooking/pasteurisation. • Farm biosecurity and slaughter hygiene.	<b>Heating:</b> Very heat-sensitive. <b>Resistance:</b> Sensitive to drying and oxygen; survivors persist in freezing.
<i>Clostridium</i>	<i>C. botulinum</i>	<ul style="list-style-type: none"> <li>Gram+</li> <li>Rod-shaped</li> <li><b>Spore-forming</b></li> <li><b>Strict anaerobe</b> (key feature)</li> </ul>	<b>T range:</b> Wide (some grow as low as 3.3°C). <b>Requires:</b> Low oxygen, specific pH/Aw (>4.6 pH for spores to germinate).	<u>Origin:</u> Soil, sediments. <u>Food products:</u> Improperly processed canned/preserved foods, vacuum-packed products.	Very low (ng range - Toxin)	<b>Botulism:</b> Potent neurotoxin causes flaccid paralysis, respiratory failure, death. Onset: 12-72 hours.	<b>• Reg. (EC) 852-3/2004:</b> GHP. <b>Standards:</b> Canned foods must achieve 12-D reduction (Botulinum Cook).	<b>• Critical: Validated thermal processing</b> (retorting) for low-acid canned foods. • Formulation control (Aw, pH, NaCl). • Strict refrigeration (<3°C) for non-heat treated chilled products.	<u>Toxin:</u> Heat-sensitive (>85°C/5min). <u>Spores:</u> <b>Extremely heat-resistant</b> (requires >121°C). <u>Vegetative cells:</u> Killed by oxygen.
<i>Clostridium</i>	<i>C. perfringens</i>	<ul style="list-style-type: none"> <li>Gram+</li> <li>Large rod-shaped</li> <li><b>Spore-forming</b></li> <li><b>Strict anaerobe</b></li> </ul>	<b>Optimum T:</b> 43-45°C (rapid growth).	<u>Origin:</u> Soil, gut of humans/animals. <u>Food products:</u> Cooked meat, poultry, gravies, stews (large batches, slow-cooled).	High (>10 <sup>6</sup> cells ingested)	<b>Food poisoning:</b> Intense abdominal cramps, watery diarrhoea. Onset: 8-22h.	<b>• Reg. (EC) 2073/2005:</b> No specific criteria. <b>• Reg. (EC) 852-3/2004:</b> GHP.	<b>• Critical: Rapid cooling</b> of cooked foods. Hot holding (>60°C). • Division of large batches for faster cooling. • Thorough reheating.	<u>Vegetative cells:</u> Heat-sensitive (>60°C). <u>Spores:</u> Heat-resistant (germinate during slow cooling). <u>Resistance:</u> Spores are resistant to drying, freezing.

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<i>Coxiella</i>	<i>C. burnetii</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Coccobacillus</li> <li>Spore-like SCV</li> <li><b>Obligate intracellular</b></li> </ul>	N/A (does not grow in food)	<u>Origin:</u> Infected animals (goats, sheep, cattle). <u>Food products:</u> Unpasteurised milk and dairy products.	Very low (1-10 cells)	<b>Q Fever:</b> Flu-like illness, pneumonia, hepatitis. Chronic form (endocarditis) possible.	<b>• Reg. (EC) 853/2004:</b> GHP. Milk pasteurisation required.	<b>• Critical: Validated pasteurisation</b> (the legal standard is set to inactivate this pathogen). • Sourcing milk from healthy herds.	<b>Heating:</b> Most heat-resistant non-spore-former (legal standard for milk pasteurisation is based on this). <b>Resistance:</b> Highly resistant to drying, UV, and sanitizers.
<i>Cronobacter</i>	<i>C. sakazakii</i> & spp.	<ul style="list-style-type: none"> <li>Gram-</li> <li>Rod-shaped</li> <li>Biofilm-former</li> </ul>	<b>T range:</b> Wide (grows as low as 6°C). <b>Optimum T:</b> 37-40°C.	<u>Origin:</u> Ubiquitous in environment, processing plants. <u>Food products:</u> Powdered infant formula (PIF), dried milk products.	Low (<10 cells for infants)	<b>Severe infections in infants:</b> Meningitis, sepsis, necrotizing enterocolitis. High mortality rate.	<b>• Reg. (EC) 2073/2005:</b> Strict criterion for PIF (Absence in 30 x 10g samples).	<b>• Critical: Hygienic design</b> of plant; <b>rigorous dry cleaning</b> and sanitation. • Environmental monitoring program (EMP). • GHP during PIF reconstitution (≥70°C water).	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> <b>Extremely resistant to drying</b> and low water activity.
<i>Escherichia</i>	STEC/VTEC: <i>E. coli</i> O157:H7, O26, O103	<ul style="list-style-type: none"> <li>Gram-</li> <li>Rod-shaped</li> <li>Motile</li> <li>Biofilm-former</li> </ul>	<b>T range:</b> Wide (grows from 7°C). <b>Resistant to acid.</b>	<u>Origin:</u> Intestinal tract of cattle/ruminants. <u>Food products:</u> Undercooked ground beef, raw milk, contaminated produce (sprouts), unpasteurised juice.	Low (<100 cells)	<b>Haemorrhagic colitis</b> (bloody diarrhoea). <b>Haemolytic Uraemic Syndrome (HUS)</b> (kidney failure).	<b>• Reg. (EC) 2073/2005:</b> Criteria for sprouts and as indicator organism.	<b>• Critical: Validated thermal processes</b> (cooking meat thoroughly). • Cross contamination prevention. • Good Agricultural Practices (GAPs). • Effective cleaning of produce/seeds.	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Survives low pH (acid); survives freezing.
<i>Listeria</i>	<i>L. monocytogenes</i>	<ul style="list-style-type: none"> <li>Gram+</li> <li>Rod-shaped</li> <li>Biofilm-former</li> <li>Facultative anaerobe</li> </ul>	<b>T range:</b> Wide ( <b>psychrotrophic - grows at 0°C</b> ). <b>Resistant to salt</b> (10% NaCl).	<u>Origin:</u> Ubiquitous in environment, processing niches. <u>Food products:</u> RTE deli meats, soft cheeses, smoked fish, pâté, chilled ready meals.	Low (<1000 cells for susceptible groups)	<b>Listeriosis:</b> Invasive disease (meningitis, septicemia). High fatality rate. Severe risk for pregnant women, newborns, elderly (YOPI).	<b>• Reg. (EC) 2073/2005:</b> Strict criteria for RTE foods (<100 CFU/g, or Absence in 25g).	<b>• Critical: Post-lethality sanitation</b> and <b>EMP</b> (focus on drains/niches). • Validated thermal processes. • Growth inhibitors (lactate, diacetate). • Validation to ensure <100 CFU/g limit is met throughout shelf-life.	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Grows in refrigeration, resistant to salt and low pH.

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<i>Mycobacterium</i>	<i>M. bovis</i>	<ul style="list-style-type: none"> <li>• Acid-fast bacilli</li> <li>• Rod-shaped</li> <li>• Aerobe</li> </ul>	N/A (does not grow in food)	<u>Origin:</u> Infected cattle (bovine tuberculosis). <u>Food products:</u> Unpasteurised milk and dairy products.	Low (<10 cells)	<b>Tuberculosis (TB):</b> Chronic, systemic disease, often affecting lungs and lymph nodes.	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 853/2004:</b> Requires milk pasteurisation.</li> <li>• <b>Reg. (EU) 2016/429:</b> Eradication and surveillance.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Critical: Validated pasteurisation.</b></li> <li>• Sourcing milk from officially TB-free herds.</li> <li>• Meat inspection.</li> </ul>	<b>Heating:</b> Heat-sensitive (standard pasteurisation conditions). <b>Resistance:</b> Waxy cell wall provides resistance to many sanitizers and drying.
<i>Salmonella</i>	<i>S. enterica</i> ( <i>Enteritidis</i> , <i>Typhimurium</i> )	<ul style="list-style-type: none"> <li>• Gram-</li> <li>• Rod-shaped</li> <li>• Motile</li> <li>• Biofilm-former</li> </ul>	<b>T range:</b> Wide (grows from 5°C). <b>Optimum T:</b> 37°C.	<u>Origin:</u> Intestinal tract of many animals/humans. <u>Food Products:</u> Raw poultry, eggs, meat, produce, low-Aw foods (chocolate, spices).	Low (<20 cells possible)	<b>Salmonellosis:</b> Fever, diarrhoea, cramps, vomiting. Severe systemic illness possible.	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 2073/2005:</b> Strict criteria for RTE foods (Absence in 25g/10g).</li> <li>• <b>Reg. (EC) 2160/2003:</b> EU-wide control programs in poultry.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Critical: Validated thermal processes.</b></li> <li>• Cross contamination prevention.</li> <li>• Control programs in animal production and slaughter hygiene.</li> </ul>	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Extremely resistant to drying/low water activity (survives years in low-Aw foods).
<i>Shigella</i>	<i>S. sonnei</i> , <i>S. flexneri</i> , <i>S. dysenteriae</i>	<ul style="list-style-type: none"> <li>• Gram-</li> <li>• Rod-shaped</li> <li>• <b>Non-motile</b></li> </ul>	<b>Optimum T:</b> 37°C.	<u>Origin:</u> Intestinal tract of humans and primates only (fecal contamination). <u>Food products:</u> Foods handled extensively (salads, sandwiches), contaminated water.	Very low (10-200 cells)	<b>Shigellosis (Bacillary Dysentery):</b> Bloody diarrhoea, cramps, fever. Shiga toxin causes severe illness.	<ul style="list-style-type: none"> <li>• <b>Reg. (EC) 2073/2005:</b> No specific criteria.</li> <li>• <b>Reg. (EC) 853-4/2004:</b> GHP (focus on handler hygiene).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Critical: Strict GHP for food handlers</b> (effective handwashing).</li> <li>• Exclusion of ill staff.</li> <li>• Prevention of bare-hand contact with RTE foods.</li> </ul>	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Survives low pH (acid).

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<i>Staphylococcus</i>	<i>S. aureus</i>	<ul style="list-style-type: none"> <li>Gram+</li> <li>Cocci (clusters)</li> <li>Biofilm-former</li> </ul>	<b>T range:</b> Wide (grows from 7°C). <b>Highly resistant to low Aw</b> (grows down to 0.83). <b>Highly salt tolerant</b> (up to 20% NaCl).	<u>Origin:</u> Humans (skin, nose, throat, cuts). <u>Food products:</u> Foods requiring handling and temperature abuse (salads, creams, cured meats, raw milk cheese).	Toxin dose: >1 µg (from >10 <sup>5</sup> CFU/g)	<b>Food poisoning (Intoxication):</b> Severe nausea, forceful vomiting, cramps, caused by <b>heat-stable toxin</b> produced in food.	<b>• Reg. (EC) 2073/2005:</b> Process hygiene criteria (e.g., cheese). Levels >10 <sup>5</sup> CFU/g trigger toxin testing.	<b>• Critical: Temperature control</b> (hot >60°C or cold <7°C) to prevent growth and toxin production. <b>• Strict GHP for food handlers.</b>	<u>Vegetative cells:</u> Heat-sensitive. <u>Toxin:</u> <b>Extremely heat-resistant</b> (survives UHT/canning). <u>Resistance:</u> Highly resistant to drying and salt.
<i>Vibrio</i>	<i>V. parahaemolyticus</i> , <i>V. vulnificus</i> , <i>V. cholerae</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Curved rod-shaped</li> <li>Motile</li> <li><b>Halophilic</b> (requires salt)</li> </ul>	<b>T range:</b> Wide (grows from 5°C). <b>Requires salt</b> (optimum 1-3%).	<u>Origin:</u> Marine and estuarine environments (saltwater). <u>Food products:</u> Raw or undercooked seafood (oysters, clams, fish).	Low to High	<b>Vibriosis:</b> Watery diarrhoea. <u>V. vulnificus:</u> Life-threatening septicemia. <u>V. cholerae:</u> Cholera (severe dehydration).	<b>• Reg. (EC) 2073/2005:</b> No specific criteria. <b>• Reg. (EC) 853-4/2004:</b> GHP.	<b>• Critical: Rapid chilling</b> (immediately post-harvest, ideally <5°C) of shellfish. <b>• Harvest from approved waters.</b> <b>• Validated post-harvest treatments</b> (e.g., HPP).	<b>Heating:</b> Very heat-sensitive. <b>Inactivation:</b> Acid, HPP, irradiation.
<i>Yersinia</i>	<i>Y. enterocolitica</i> , <i>Y. pseudotuberculosis</i>	<ul style="list-style-type: none"> <li>Gram-</li> <li>Coccobacillus</li> <li>Motile at low T</li> </ul>	<b>T range:</b> Wide ( <b>psychrotrophic - grows as low as -1°C</b> ).	<u>Origin:</u> Intestinal tract of pigs (main reservoir). <u>Food products:</u> Raw/undercooked pork (esp. offal), raw milk, contaminated foods.	High (10 <sup>4</sup> - 10 <sup>9</sup> cells)	<b>Yersiniosis:</b> Fever, abdominal pain (mimicking appendicitis), diarrhoea. Sequelae: Reactive arthritis.	<b>• Reg. (EC) 2073/2005:</b> No specific criteria. <b>• Reg. (EC) 853-4/2004:</b> Pig hygiene.	<b>• Critical: Prevent cross-contamination</b> from raw pork. <b>• Careful evisceration at slaughter.</b> <b>• Validated thermal processes</b> (cooking/pasteurisation).	<b>Heating:</b> Heat-sensitive. <b>Resistance:</b> Grows in refrigeration (key hazard), freezing.