

Salmonella species

1. What are *Salmonella* spp.?

Salmonella spp. are a group of bacteria which reside in the intestinal tract of human beings and warm blooded animals and are capable of causing disease. They are the second most common cause of bacterial foodborne illness in Ireland (*Campylobacter* spp. is the most frequent cause). They are facultative anaerobic Gram-negative rods.

Salmonella spp. are members of the *Enterobacteriaceae* group. The genus *Salmonella* contains 2 species:

- *Salmonella enterica*
- *Salmonella bongori*

Salmonella enterica is an important agent of foodborne illness. This species is sub-classified into 6 subspecies of which *S. enterica* subspecies *enterica* is the most important for human health.

The genus *Salmonella* can be subdivided into more than 2,400 serotypes. *Salmonella enterica* subsp. *enterica* serotype Typhimurium (*S. Typhimurium*) and *Salmonella enterica* subsp. *enterica* serotype Enteritidis (*S. Enteritidis*) are the most frequently isolated serotypes in humans in Ireland. Serotypes are further subdivided by their resistance to bacteriophages (phage types or lysotypes), antibiotics or heavy metals; their biochemical characteristics (biovars or biotypes) or their sensitivity to or production of bacteriocins.

2. Growth and Survival Characteristics

Table 1. Factors affecting the growth of *Salmonella* spp.

CONDITIONS	MINIMUM	OPTIMUM	MAXIMUM
Temperature (°C)	5.2*	35 – 43	46.2
pH	3.8	7 – 7.5	9.5
Water activity (a_w)	0.94	0.99	>0.99

* Most serotypes fail to grow at < 7°C

Salmonella spp. are not particularly heat resistant and most serotypes are killed by normal cooking conditions, i.e. cooking to a core temperature of 75°C instantaneously or an equivalent time temperature combination, e.g. 70°C for 2 minutes. However, a few highly heat resistant serotypes have been reported, e.g. *S. Senftenberg* 775W and *S. Irumu*. Heat resistance is influenced by water activity (a_w), nature of the solutes and pH of the suspending medium. Greater heat resistance is observed for cells in sucrose compared with NaCl at the same a_w values. Heat resistance also increases with increasing concentration of milk solids.

Heat resistance* of *S. Typhimurium* in milk chocolate at various temperatures is presented in the following table:

D-VALUE (MIN) FOR <i>S. TYPHIMURIUM</i> IN MILK CHOCOLATE	
90°C	75
80°C	222
70°C	816

* Heat resistance is usually expressed by the D-value (i.e. the time in minutes at a given temperature to achieve a 90% reduction in the number of viable cells). ICMSF 1996 provides an extensive list of D-Values for *Salmonella* spp. under different conditions and food types.

3. Sources of *Salmonella* spp. and Routes of Transmission

Salmonella spp. reside in the intestinal tract of humans and warm blooded animals. They are shed in the faeces. Poor hygiene practices can result in the spread of this pathogen to the hands of humans while on the farm. Feet, hair and skin of animals can become contaminated as they walk, sit or lie in faecally contaminated ground or litter.

The spread of *Salmonella* spp. to carcasses may occur in the abattoir environment during slaughter. Furthermore, spread of *Salmonella* spp. to agricultural commodities may occur through faecal contamination of streams, rivers and coastal waters and the use of improperly treated sewage for agricultural purposes. In the food processing environment, spread of this pathogen can occur through cross contamination from raw food or infected food handlers.

The human infection caused by *Salmonella* spp. is referred to as salmonellosis. Although salmonellosis can arise from contact with infected animals, consumption of contaminated food is the most usual cause.

4. *Salmonella* spp. and Food

Many foods have been identified as vehicles for the transmission of this pathogen to humans, particularly foods of animal origin but also foods of non-animal origin which may be subject to faecal contamination. Those of particular importance include eggs, pig meat, poultry meat, milk, chocolate, fruit and vegetables. It is important to note that although *Salmonella* spp. do not form spores, they can survive for long periods in foods.

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5. The Illness (salmonellosis)

In recent years in Ireland, *S. Typhimurium* and *S. Enteritidis* have accounted for the majority of human cases of salmonellosis. Symptoms usually appear 12-36 hours after the ingestion of contaminated food. Symptoms include acute enterocolitis with sudden onset of headache, abdominal pain, diarrhoea, nausea, vomiting and fever. Dehydration may occur particularly among vulnerable populations, e.g. infants, the immuno-compromised and the elderly. The condition usually lasts 2-5 days and is generally self limiting. Complications can lead to systemic infections and can result in various chronic conditions such as reactive arthritis. The infective dose can vary depending on the strain, the immuno-competence of the individual and the nature of the food. Data from outbreaks of foodborne diseases suggest that infections may be caused by the ingestion of as few as 10-45 cells.

S. Typhi and *S. Paratyphi* can cause enteric (typhoid) fever, a severe systemic life threatening condition, but it is very rare in Ireland and is mostly travel associated.

For further information on salmonellosis please refer to the Health Protection Surveillance Centre (HPSC) website:

<http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/Salmonellosis/Factsheet/>

6. Incidence of the Disease

Salmonellosis (other than typhoid and paratyphoid) is a notifiable disease in Ireland. In Ireland, 333 cases of salmonellosis (1 of these cases was not laboratory confirmed) were reported to the HPSC in 2009, corresponding to a crude incidence rate (CIR) of 7.9 cases per 100,000 population. This was a decrease on the 2008 CIR which was 10.6 cases per 100,000 population.

This illness shows a marked seasonality with a peak occurring between May and October. The highest numbers of travel associated salmonellosis notifications are reported during this period.

All age groups are affected by this disease but the highest incidence occurs in the 0-4 age group. This is likely to be a reflection of clinicians more readily seeking clinical samples from this age group. Both males and females are equally affected (statistics available from the HPSC).

In the European Union (EU), a total of 108,614 confirmed cases of human salmonellosis were reported in 2009 from 27 Member States. The overall incidence in the EU was 23.7 per 100,000 population.

7. Foodborne Outbreaks of Salmonellosis

In Ireland, 15 outbreaks of *S. enterica* (3 general and 12 family outbreaks) were notified to the HPSC in 2009. These resulted in 93 persons being ill and 1 death.

Foodborne transmission was suspected for the 3 general outbreaks and for 2 of the 12 family outbreaks. Regarding the 3 general outbreaks, 1 was caused by a mixture of *Salmonella* Kentucky and *S. Agona* strains resulting in 35 cases of illness, 7 of which were laboratory confirmed. The other 2 outbreaks were caused by *S. Typhimurium* DT193 resulting in 12 laboratory confirmed cases and *S. Enteritidis* 14b resulting in 19 confirmed cases, including 1 person who died. In all 3 outbreaks, no specific food item was implicated.

In the EU, 1,722 foodborne outbreaks of human salmonellosis were reported in 2009. This represented 31.0% of the total number of reported foodborne outbreaks in the EU.

8. Legislation

All food business operators have a legal responsibility to produce safe food (Regulation 178/2002)¹. The safety of foodstuffs is ensured by a preventative approach, i.e. the implementation of a food safety management system based on the principles of Hazard Analysis and Critical Control Point (HACCP). This system enables hazards to be identified and controlled before they threaten the safety of food. All food business operators, with the exception of primary producers, are legally obliged to put in place, implement and maintain a permanent procedure or procedures based on HACCP principles (Article 5 of Regulation 852/2004)². Furthermore, all food business operators, including primary producers, are legally obliged to implement good hygiene practices (GHP). Regulation 852/2004 lays down hygiene requirements for all foodstuffs; while Regulation 853/2004³ lays down more specific hygiene requirements for foods of animal origin.

Regulation 2073/2005⁴ lays down microbiological criteria for various combinations of food commodities and microorganisms, their toxins or metabolites. It requires food business operators to take measures, as part of their procedures based on GHP and HACCP principles, to ensure compliance with the relevant microbiological criteria. Food business operators should test against these criteria, as appropriate, when validating and verifying the correct functioning of these procedures.

The Regulation differentiates microbiological criteria into:

- 1) Process hygiene criteria:** These criteria indicate if the production process is operating in a hygienic manner. They are applicable to foodstuffs at various stages throughout their production processes, e.g. process hygiene criteria are established for *Salmonella* spp. in carcasses of cattle, sheep, goat, horses, pigs and poultry)
- 2) Food safety criteria:** These criteria define the acceptability of a foodstuff in terms of its microbiological safety. They are applicable to foodstuffs placed on the market during their shelf-life, e.g. food safety criteria are established for *Salmonella* spp. in meat and meat products, dairy products, egg products, fish and fishery products and fruit and vegetables.

Please note: Food business operators should be aware of their obligations in these and other pieces of legislation. It is the responsibility of the food business operator to keep up-to-date with all amendments to legislation. For further information on the legislation, please consult the Food Safety Authority of Ireland (FSAI) website: http://www.fsai.ie/legislation/food_legislation.html.

¹ Regulation (EC) No 178/2002 of The European Parliament and of The Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

² Regulation (EC) No 852/2004 of The European Parliament and of The Council of 29 April 2004 on the hygiene of foodstuffs

³ Regulation (EC) No 853/2004 of The European Parliament and of The Council of 29 April 2004 laying down specific hygiene rules for food of animal origin

⁴ Commission Regulation (EC) No 2073/2005 of 15 November 2005 on Microbiological Criteria for Foodstuffs

9. Control of *Salmonella* spp. in the Food Chain

Since low numbers of *Salmonella* spp. can cause illness, it is important that control measures are taken at all stages in the food chain. These are essential to protect the health of consumers and the integrity of the business. Examples of control measures include:

- Implementation of Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) at all stages in the food chain, i.e. at farm level, slaughterhouse, manufacturing, processing, catering, retail etc. Particular attention should be paid to the prevention of cross contamination between raw and ready-to-eat foods
- Implementation of a food safety management system based on the principles of HACCP. This includes good process control, e.g. temperature control during cooking, storage
- Testing against microbiological criteria, as appropriate, when validating and verifying the correct functioning of their HACCP based procedures and other hygiene control measures

References/Further Reading

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