

Staphylococcus aureus

1. What is *Staphylococcus aureus*?

S. aureus is a bacterium belonging to the genus *Staphylococcus*. Staphylococci are toxin producing, Gram-positive, catalase positive cocci which grow aerobically but which are capable of facultative anaerobic metabolism. Staphylococcal foodborne intoxication is a common cause of bacterial food poisoning.

2. Sources of *S. aureus*

S. aureus is an ubiquitous organism occurring on the skin and mucous membranes of most warm blooded animals including all food animals and humans. It is commonly detected in foods of animal origin such as raw meat and raw bulk milk; however, it is a poor competitor and rarely causes food poisoning in raw products (an exception being milk from a mastitic cow). Approximately 50% of humans are carriers of this organism and food handlers are frequently implicated in the transmission of this pathogen to food. In addition, the organism survives well in the environment of food factories where it may become part of the flora of the processing equipment and act as a source of contamination or recontamination.

3. Staphylococcal enterotoxins

Staphylococcal enterotoxins (SEs) can be produced in food by many strains of *S. aureus* and by some other coagulase-positive staphylococci, e.g. *S. intermedius*, *S. hyicus*, *S. delphini*. The enterotoxigenic strain needs to grow to levels $>10^5$ cfu/g before the toxin is produced at detectable levels. In addition, SE formation is influenced by parameters such as temperature, pH, water activity, redox potential and bacterial antagonisms, e.g. starter cultures used in the production of fermented milk products can prevent *S. aureus* growth and SE production. Once formed, SEs are extremely difficult to eliminate from foods. They are resistant to heat, freezing and irradiation. They will survive commercial pasteurisation processes and may even survive processes used for the sterilisation of canned foods. Currently, 16 types of SE have been identified (A, B, C1, C2, C3, D, E, G, H, I, J, K, L, M, N and O).

4. Growth and Survival Characteristics (*S. aureus* and SE production)

Table 1. Factors affecting the growth of *S. aureus* and the production of SE

FACTOR	GROWTH OF <i>S. AUREUS</i>		SE PRODUCTION	
	OPTIMUM	RANGE	OPTIMUM	RANGE
Temperature (°C)	37	7 – 48	40 – 45	10 – 48
pH	6-7	4 – 10	7 – 8	4 – 9.6
Water activity (a_w)	0.98	0.83 – >0.99 ¹	0.98	0.85 – >0.99 ²
NaCl (%)	0	0 – 20	0	0 – 10
Redox potential (E_h)	>+200mV	<-200mV to >+200mV	>+200mV	<-100mV to >+200mV
Atmosphere	Aerobic	Anaerobic-aerobic	Aerobic (5 – 20% dissolved O ₂)	Anaerobic – aerobic

¹ Aerobic (anaerobic 0.90 - >0.99)

² Aerobic (anaerobic 0.92 - >0.99)

Once formed, SEs are extremely difficult to eliminate from foods. They are resistant to heat, freezing and irradiation (Table 2).

Table 2. Factors affecting the destruction of *S. aureus* and SE

FACTOR	<i>S. AUREUS</i>	SE
Heat*	Broth (D _{60°C}) 0.43 – 8.0 min	Broth (D _{121°C}) 3.0 – 8.0 min
Irradiation (D – kGy)	0.1 – 0.6	>30
Drying, chilling, freezing, ambient storage	Resistant	Resistant

* Resistance to heat is expressed as D-value, i.e. the time in minutes at a given temperature to achieve a 90% reduction in the number of viable cells.

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5. Staphylococcal Food Poisoning

Staphylococcal food poisoning occurs after the ingestion of food contaminated with the SE(s). Staphylococcal food poisoning is mainly caused by human strains of *S. aureus* producing SE(A) and/or SE(D), with the majority of strains producing SE(A) alone.

The amount of toxin necessary to cause illness depends on the susceptibility of the person; however, epidemiological studies have shown that as little as 1µg of SE can cause food poisoning. It should be noted that to produce this amount of SE, an enterotoxigenic strain needs to grow to levels of 10^5 to 10^6 cells per gram or ml.

Onset of food poisoning symptoms usually occurs between 1 and 7 hours after the ingestion of food containing the SE. Symptoms include nausea, vomiting, abdominal cramps and diarrhoea. In severe cases, collapse may occur. Recovery is usually rapid, i.e. within 2 days.

6. Foodborne Outbreaks of Staphylococcal Food Poisoning

Outbreaks and sporadic cases of staphylococcal food poisoning have been linked with foods such as cheese, salami, bakery products, pasta, canned meat, canned fish and canned vegetable products. In the case of cheese, failure of the starter culture can provide an opportunity for *S. aureus* to grow and produce the SE. In the European Union, 293 foodborne outbreaks were attributed to *Staphylococcus spp.* in 2009. This represented 5.3% of all reported foodborne outbreaks.

7. Incidence of the Disease in Ireland

Staphylococcal food poisoning has been a notifiable disease in Ireland since 1st January 2004 (S.I. No. 707 of 2003). According to this legislation, medical practitioners and clinical directors of diagnostic laboratories are requested to transmit a written or electronic notification to a Medical Officer of Health. In Ireland, 1 case of staphylococcal food poisoning was reported to the Health Protection Surveillance Centre (HPSC) in both 2008 and 2009.

8. Testing of Foods for *S. aureus* and SE

The presence of large numbers of staphylococci is not sufficient cause to incriminate a specific food as the vehicle of food poisoning because not all staphylococci are enterotoxigenic. In addition, demonstration of enterotoxigenicity of food isolates is only circumstantial evidence of enterotoxigenic staphylococcal contamination and the potential for causing food poisoning cannot be ascertained without demonstrating the actual presence of the SE in a suspect food.

Conversely, neither the absence of *S. aureus* nor the presence of small numbers of bacteria is complete assurance that the food is safe (because the SE is extremely resistant and may survive processes which kill the bacterial cells).

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9. 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. The Regulation lays down process hygiene criteria for coagulase-positive staphylococci (most coagulase-positive staphylococci which cause foodborne illness are *S. aureus*) in dairy products, e.g. certain cheeses, milk powder and whey powder, and fishery products (shelled and shucked products of cooked crustaceans and molluscan shellfish). In relation to certain cheeses, the criterion applies during the manufacturing process when the number of staphylococci is expected to be the highest. For all other products, the criterion applies at the end of the manufacturing process
- 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. The Regulation lays down a food safety criterion for staphylococcal enterotoxins in certain dairy products. These products must be tested for SEs if coagulase-positive staphylococci are detected at levels $>10^5$ cfu/g (see process hygiene criteria)

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 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

10. Control of *S. aureus* in the Food Chain

- Avoid the use of raw materials which may be contaminated with high numbers of *S. aureus* (although the organism may be killed by further processing, SEs may be present and are unlikely to be removed or destroyed).
- Ensure that food handlers are aware of the importance of good hygiene practices, particularly hand washing and the need to report skin infections so that appropriate precautions can be taken.
- 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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