

Staphylococcus aureus

What is Staphylococcus aureus?

Staphylococcus aureus are gram-positive, non-motile, non-spore-forming, facultative anaerobes found naturally on the skin and in the nose of up to 50% of people. *S. aureus* can be found in air, sewage, water, humans and animals. There are many different strains of *S. aureus* found naturally, but foodborne illness is driven by the strains that produce *Staphylococcal enterotoxins* (SE). Over 20 different types of SE have been identified, and their ingestion leads to symptoms of nausea, vomiting, diarrhea and abdominal pain, typically shown within 30 minutes and resolved after 24 hours.

Five conditions must be met for Staphylococcal poisoning to occur:

1. There is a source of an enterotoxigenic strain of *S. aureus*.
2. The transfer from the source to a food takes place.
3. A food has a composition that permits growth and enterotoxin production.
4. The conditions that permit growth and enterotoxin production are met (see table below).
5. Ingestion of food containing SE in an amount to cause intoxication occurs.

The main source of contamination is humans. This means *S. aureus* is mainly controlled by following good hygiene practices: proper handwashing and avoiding touching the face will prevent the transfer from human sources to foods.

Conditions that permit **growth** and enterotoxin **production** are represented below:

Characteristic	Bacterial Cells		Enterotoxin	
	Range	Optimal	Range	Optimal
Temperature (°C)	7 – 48	37	10 – 45	37 – 45
pH	4 – 10	6 – 7	4 – 9.6	7 – 8
Water Activity (aerobic, i.e., presence of oxygen)	0.83 – 0.99	0.98	0.85 – 0.99	0.98
Water Activity (anaerobic, i.e., absence of oxygen)	0.9 – 0.99	0.98	0.92 – 0.99	0.98
Salt (%) (Water phase salt)	0 - 20	0	0 - 10	0

What types of food products are at risk?

S. aureus can be found in many different types of food products, including meats, fish and shellfish, eggs, cheese, milk, butter, salads, bakery products, specifically cream-filled bakery items and precooked meals.

In general, low-acid and high-moisture foods are susceptible to *S. aureus*.

Foods that require heat treatments are notably susceptible to staphylococcal poisoning due to:

1. The risk that the heat treatment(s) are ineffective,
2. There is an opportunity for toxin formation before or after heat treatments are applied,
3. Foods are held at improper temperatures.

How to destroy *S. aureus* bacteria and toxins with food processing?

Freezing, drying, thermal processing, irradiation, use of food additives and acidification can be effective at inactivating bacterial strains of *S. aureus*. However, processes effective at bacterial inactivation are not also effective at destroying SE. For example, *S. aureus* can be inactivated by thermal processing, whereas SE are highly heat resistant. Therefore, it is important to control the growth of *S. aureus* to limit its ability to produce SE. Utilizing multiple methods together to control the growth of *S. aureus* is the best practice.

S. aureus is sensitive to competition with other bacteria, known as bacterial antagonism. The use of competitive flora, such as starter cultures used in dairy products or fermented foods, can inhibit its growth. Inhibition by competitive flora results due to their production of acidic compounds that lowers pH, by their production of other inhibiting compounds, or by their depletion of nutritional compounds required by *S. aureus* to grow. Acidification will not inactivate formed SE.

Bacterial and SE inactivation can also be achieved by irradiation or, when it comes to surfaces, chemically using disinfectants such as hypochlorite (bleach).

How to prevent *S. aureus* toxin formation with storage?

Controlling oxygen availability is not an effective control to prevent *S. aureus* growth or toxin formation. However, modified atmosphere storage used in combination with additives can be an effective control against bacterial growth for some food products.

Holding foods at inadequate temperatures is the primary driver for *S. aureus* growth and toxin formation. Maintaining foods susceptible to *S. aureus* at

temperatures < 4 or > 60 °C is recommended to prevent its growth. Events such as buffets or farmer markets can potentially lead to susceptible foods being held within this 'Danger zone' for an extended period, which could allow for the growth and toxin formation of *S. aureus*. Following Health Canada's guidelines on preparing food will help eliminate the risk of growth and toxin formation of *S. aureus* (link below).

Following standard food handling practices, such as avoiding prolonged heat-keeping and room temperature storage, will prevent bacterial growth and toxin formation in foods prior to heat treatments.

After cooking, foods should be cooled to $< 4^{\circ}\text{C}$ within 2 hours to prevent bacterial growth. If temperature abuse occurs, this will increase susceptibility to toxin formation. Meat products have required cooling curves that must be followed to prevent bacteria growth and toxin production.

References

- Bhatia A, and Zahoor S. *Staphylococcus aureus* enterotoxins: a review. Journal of Clinical and Diagnostic Research. 3:188-197.
- Centers for Disease Control and Prevention. 2018. Staphylococcal (Staph) Food Poisoning. <https://www.cdc.gov/foodsafety/diseases/staphylococcal.html>
- Government of Canada. 2012. Pathogen safety data sheets: infectious substances – staphylococcus aureus. <https://www.canada.ca/en/public-health/services/laboratory-biosafety-biosecurity/pathogen-safety-data-sheets-risk-assessment/staphylococcus-aureus.html>
- Halpin-Dohnalek, M.I., and Marth, E.H. 1989. Staphylococcus aureus: production of extracellular compounds and behaviour in foods – a review. Journal of Food Protection. 52(4), 267-282.
- Health Canada. 2021. Food Safety and you. Food safety and you - Canada.ca
- Hennekinne, J.-A., De Buyser, M.-L., and Dragacci, S. 2011. Staphylococcus aureus and its food poisoning toxins: characterization and outbreak investigation. FEMS Microbiology Reviews .35(4), 815-836.
- Le Loir, Y., Baron, F., and Gautier, M. (2003). Staphylococcus aureus and food poisoning. Genetics and Molecular Research: GMR, 2(1), 63-76.
- Province of Nova Scotia. 2021. Food Safety Guidelines For Meat Processors. https://www.novascotia.ca/nse/food-protection/docs/Meat_Processing_Guidelines.pdf