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CROP & FOOD RESEARCH
Mana Kai Rangahau

Staphylococcus aureus

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1 Background

Staphylococcal food poisoning is caused by the consumption of food containing staphylococcal enterotoxins. For toxic levels of enterotoxin to occur, extensive multiplication (growth) of staphylococci cells generally needs to have taken place in the food. Under most seafood processing regimes, low temperatures and the presence of other bacterial species (spoilage organisms) prevent this from occurring. When staphylococci of concern, such as *Staphylococcus aureus* have been isolated from New Zealand seafood processing plants or seafood products, the numbers of contaminating organisms have generally been low and contamination has frequently been caused by a food handler who is either a carrier of *S. aureus* or has skin inflammations, eruptions or wounds infected with *S. aureus*.

2 Biology of the organism

While a range of *Staphylococcus* species can produce enterotoxins, the vast majority of outbreaks of staphylococcus food poisoning are due to the presence of *S. aureus*. *Staphylococcus aureus* is a non-motile, spherical, Gram positive microscopic bacterium (coccus) 0.5 to 1.0 μm in diameter which on microscopic examination appears in pairs, short chains, or grape-like clusters.

Staphylococcus aureus is often found closely associated with the human body. It may also be found in many parts of our environment, including dust, water, air and faeces and on clothing or utensils. Although *S. aureus* is an important pathogen, many healthy people carry it as part of the normal population of micro-organisms associated with the nose, throat, perineum or skin. The carrier rate varies in different populations. The nasal passages are reported to harbour *S. aureus* in 10-50% of the healthy population.

Staphylococcus aureus causes several infections that compromise food safety because of their frequency and the fact that they do not necessarily prevent the infected person from working. Various types of skin eruptions and inflammations (boils, acne, styes, etc.) and wounds, sometimes as small as minor damage around fingernails, can harbour large numbers of the organisms. *Staphyloccocus aureus* can also cause respiratory infections or may become established in the gut, causing enteritis.

Staphylococcus aureus is considered to be a poor competitor in complex microbial populations and is frequently inhibited or overgrown by other faster growing micro-organisms (spoilage organisms) in foods. Therefore, foods that present the greatest risk of staphylococcal food poisoning are those where the normal microflora has previously been destroyed (e.g. cooked products) or inhibited (e.g. foods that contain a high concentration of salt) but that have subsequently been contaminated by *S. aureus.*

Illness results when pre-formed toxins in the food are eaten at high enough levels, after significant growth of *S. aureus* has occurred. This is because the staphylococcal enterotoxins are produced at low levels while the organisms are growing at their fastest rate (exponential growth), and the toxin production rate increases dramatically as growth starts to slow (late exponential or early stationary phase) when nutrients become scarce or waste products start to build up. A toxin level of less than 1.0 μg has been reported to cause staphylococcal intoxication, a concentration that is reached when *S. aureus* populations exceed 100 000 cells per gram.

Enterotoxins are relatively difficult to destroy by heating. The usual heat treatments used to cook food and destroy bacterial cells cannot be relied upon to inactivate the toxin. When foods are tested to assess their safety, both the presence of residual toxin as well as viable micro-organisms are determined.

3 Growth

The nutritional requirements of *S. aureus* are complex and vary from strain to strain. The conditions under which this bacteria grows (growth parameters, Table 1) also depend on the composition of the food.

The range of environmental parameters over which *S. aureus* will produce enterotoxins can be narrower than the range over which it will grow. It is possible for *S. aureus* to grow without producing enterotoxin.

In general, *S. aureus* grows between 7 and 47°C, with an optimum of 30-37°C. Enterotoxins are produced between 10 and 46°C, with an optimum of 35-45°C. Enterotoxin production is substantially reduced at 20-25°C. It is generally accepted that enterotoxin production is unlikely to occur at temperatures below 10°C.

Optimum enterotoxin production occurs at pH 6-7 and is influenced by atmospheric conditions, carbon and nitrogen source and salt level. Reduced levels of water activity (a_w) may also inhibit toxin synthesis more than growth. Optimum growth and toxin production occur at a_w levels > 0.99. Toxin production has been reported at as low as a_w = 0.86.

Table 1: Physical parameters limiting S. aureus growth.

Min. a_w	Min. pH	Max pH	Max % salt	Min. temp (°C)[1]	Max. temp (°C)[1]	Oxygen requirement
0.83	4.0	9.8	7-10 up to 20	6-7	45-47	Facultative anaerobe[1]

[1] Will grow in the presence or absence of oxygen, but grows best in its presence.

4 Survival

Staphylococcus aureus is a hardy organism that withstands desiccation well, and can survive in dust and on dry metal, glass, or porcelain surfaces for long periods of time. This organism has a high heat resistance for a non-sporing bacteria, with D values at 60^{o}C being reported to range from 2 to 50 minutes depending on the food.

Most chemical sanitisers used routinely in the food industry, including chlorine, other halogens and quaternary ammonium compounds, will destroy *S. aureus* on surfaces when applied correctly. However, cells that recovered after exposure to sanitisers among populations established on poultry processing equipment were subsequently more resistance to them.

5 Nature of the disease

Staphyloccocal food poisoning is one of the most common types of foodborne disease worldwide. It has been identified as the causative agent in numerous outbreaks of food posioning, but is believed to be under reported due to the self-limiting nature of the illness and the fact that most people recover within 1-2 days of becoming ill.

The onset of symptoms in staphylococcal food poisoning can be very rapid, generally around 3 hours after ingestion of the food but may be as early as 1 h or as late as 6 hours, depending on individual susceptibility to the toxin, the amount of contaminated food eaten, the amount of toxin in the food, and the general health of the individual. The most common symptoms are nausea, vomiting, retching, abdominal cramping, and prostration. Some individuals may not demonstrate all of the symptoms associated with the illness. In more severe cases, headache, muscle cramping, and transient changes in blood pressure and pulse rate may occur. Blood may be observed in stools and vomitus. Recovery generally takes two days, However, it is not unusual for complete recovery to take three days or longer in severe cases.

6 Associated foods

Foods that are frequently implicated in staphylococcal food poisoning include meat and meat products, poultry and egg products, and salads such as egg, tuna, chicken, potato, and macaroni. Also implicated are bakery products such as cream-filled pastries, cream pies, chocolate eclairs, sandwich fillings, and milk and dairy products. Foods that require considerable handling during preparation and that are kept at slightly elevated temperatures after preparation are frequently involved in staphylococcal food poisoning.

7 Sources of contamination

Food handlers are usually the main source of food contamination. However, the surfaces of equipment can also be a source of *S. aureus* contamination.

8 Control

Due to the high incidence of *S. aureus* carriage by humans, prevention of staphyloccoal food poisoning relies on good hygienic practices to reduce the incidence of contamination of food by food handlers. This is followed by the implementation of control procedures, such as cooking or chilling, to prevent growth and toxin production by any contaminating staphylococci. In seafood processing plants, low temperature storage and the presence of competitive spoilage organisms generally ensure that *S. aureus* does not pose a health risk.

Staphylococcus aureus has sometimes caused problems in New Zealand seafood processing plants as it can prove difficult to track down the source of typically low numbers of cells during routine checks. In these cases the source has frequently been found to be the hands, nose, mouth or a septic lesion of a person handling the food. Consequently, the personal hygiene of food handlers is of paramount importance. People with wound infections or inflammations such as acne or boils need to take particular care. Likewise, touching the nose when processing food, sneezing or coughing over food should be avoided.

Bactericidal soaps and creams can be useful in reducing the carriage of *S. aureus* on hands. Antibiotic or antiseptic cream may be of use to treat workers who have high levels of *S. aureus* in their nose. In some instances, limiting the contact that chronic carriers have with food may be the best option. Using utensils and disposable gloves is certainly advantageous.

Good temperature control can prevent the growth of staphylococci in prepared foods. Foods should be kept at 60°C or above or 7.2°C or below.

9 Food safety regulations

Under the current regulations, guidelines for unacceptable numbers of specified micro-organisms such as *S. aureus* are only given for a limited range of products. Processors need to address hazards and their control via a HACCP plan.

Food Standards Australia New PART 1.6 Microbiological and Processing Requirements, Standard 1.6.1, Microbiological Limits for Food, New Zealand (http://www.anzfa.gov.au/foodstandardscode/) applies the following to coagulase positive (predominantly *S. aureus*) staphylococci:

Raw or cooked crustacea

n = 5, c = 0, m = 10^2, M = 10^3

n is the minimum number of sample units that must be examined from a lot of food.

c is the maximum allowable number of defective samples allowed.

m is the acceptable microbiological level in a sample unit.

M is the level specified that, when exceeded in one or more samples, would cause the lot to be rejected.

10 Acknowledgment

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Web links for additional information on *Staphylococcus aureus*

US/FDA Bad Bug Book

http://www.cfsan.fda.gov/~mow/chap3.html

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