

Microbial update

Staphylococcus aureus

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In a series of research papers published in the 1880s, the Scottish surgeon Sir Alexander Ogston first noted the name staphylococcus. The organisms he was observing were isolated from pus taken from human abscesses, and the name he used was derived from Greek nouns: staphyle; meaning bunches of grapes, and coccus; meaning a grain or berry.

He clearly showed that the inoculation of mice with these isolates resulted in a pyogenic (pus producing) disease and a few years later Rosenbach named a staphylococcus producing yellow/orange colonies, *Staphylococcus aureus* (aureus meaning golden in Latin).

The first known association of staphylococci with food poisoning was in 1884, when Vaughan and Sternberg described a large outbreak of illness in Michigan apparently linked with eating cheese. It was 1914 when the link to food poisoning was finally confirmed by Barber who showed that consuming milk from a cow with staphylococcal mastitis, caused illness.

The fact that the causative agent was not the organism itself, but a toxin, was established by Dack in 1930, with the demonstration that a sterile filtrate, from a culture of yellow staphylococcus caused illness in human volunteers.

Since that time, *Staphylococcus aureus* has been shown to be the cause of large number of outbreaks of food poisoning all around the world.

What is it?

Staphylococci are non-motile, facultatively anaerobic, Gram positive, catalase positive cocci (spheres). They divide in more than one plane forming irregular three dimensional clusters of cells. There are over 30 different species within the genus staphylococcus.

Although food microbiologists often talk about *S. aureus* as the species that causes food poisoning, it is one of a number of 'coagulase positive staphylococci' that have been linked to outbreaks and incidents.

Both *S. hyicus* and *S. intermedius* have been shown to produce toxins that cause



food poisoning, indeed the latter organism has been linked to a large outbreak in dairy spread in the early 1990s.

Unlike many foodborne illnesses that are caused by the growth of an infective pathogen within the gut of the host, staphylococcal food poisoning is caused by a chemical toxin that is produced by the organism as it grows within the food.

When this toxin is consumed it causes the classic food poisoning symptoms of staphylococcal food poisoning.

What does it cause?

Staphylococcal food poisoning is caused by eating foods contaminated with toxins produced by *Staphylococcus aureus*. Foods can be contaminated in many ways, however, staphylococci all tend to originate on the skin or the mucous membranes of animals (including humans) where they form part of the normal microbial population and can be quite harmless.

Once in foods, however, the organism can, under the right conditions, begin to grow. During growth the organism can produce a range of toxins including the 'enterotoxins' known to cause food poisoning. These are only produced when the staphylococci grow, and quite high numbers are needed to produce sufficient toxin to cause human illness, some reports suggest 10^5 to 10^6 per g or ml of food. In terms of the toxin itself, it is generally accepted that $1 \mu\text{g}$ of toxin can cause illness. Once formed within

a food, the toxin is virtually impossible to eliminate with reports clearly showing that toxins remain active and able to cause food poisoning after boiling or even heating to 121°C for several minutes.

This brings about one of the strange effects that can be seen in outbreaks of staphylococcal food poisoning. If the organism has grown in a food or ingredient forming toxin, and subsequently that food is cooked, then the food may appear to be microbiologically acceptable containing no pathogens and a low microbial count, however, the preformed toxin will still be present and active and will be able to cause food poisoning when consumed.

Once consumed, staphylococcal toxins are fast acting, sometimes causing illness in as little as 30 minutes. Symptoms usually develop within one to six hours after eating contaminated food, the speed and symptoms depending on the susceptibility of the patient, the amount of toxin within the food and the amount of food consumed.

Patients can experience any one of a range of symptoms including: nausea, vomiting, stomach cramps, and diarrhoea. The illness is usually mild and most patients recover after about a day. In a small minority of patients the illness may be more severe.

The numbers of outbreaks of staphylococcal food poisoning seen in official reports from health protection agencies, can tend to look low compared to those seen with campylobacter or salmonella. However, there is a general agreement that due to the relatively mild and short lived symptoms,

many cases of staphylococcal food poisoning go unreported, and we do not know the real burden of illness from this organism.

There are mandatory criteria for staphylococci in some regulations. These may vary country by country, but within Europe manufacturers should consult with Commission Regulation 2073 and check national regulations to ensure that they are aware of any mandatory criteria that may affect the foods that they produce.

Where does it come from?

As noted previously, staphylococci tend to originate from the skin and membranes (mouth, throat, nose) of animals, including humans. Food can be initially contaminated, usually with low levels of organism, simply through poor hygiene.

The touching of foods by unwashed hands, or contact of hands with the face particularly around the nose and mouth, followed by hand contact with foods, are all classic ways of contaminating food materials and ingredients.

Staphylococci also exist in air, dust, sewage, water, milk or on food equipment and environmental surfaces but still food handlers are usually the main source of food contamination in food poisoning outbreaks.

Foods that are frequently associated with staphylococcal food poisoning include meat, meat products, poultry, egg products, salads (egg, tuna, chicken, potato, and pasta), bakery products (cream-filled pastries, cream pies, and chocolate éclairs), sandwich fillings, 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. For levels of staphylococci high enough to cause food poisoning to develop, the organism has to be able to grow in the food.

Therefore contaminated foods have to have conditions of pH, water activity and temperature that will allow the organisms to grow, these intrinsic and extrinsic factors are key to preventing the growth of staphylococci, and will form a key control measure in susceptible foods.

Control measures

Staphylococci can be controlled well by the standard techniques used to control other organisms. Water activity, pH, heat processing and chill storage can all be used. Normal cooking regimes will inactivate staphylococci easily and can be used to eliminate the organism from ingredients or products.

Once cooked good hygienic measures have to be used to prevent recontamination, and of course, if staphylococci have already grown and produced toxin, then cooking will be of little use.

These organisms can grow at lower water



activities than other food pathogens, with an Aw of 0.83 being required to stop growth, however it is reported that higher water activities may be sufficient to prevent enterotoxin formation, even though growth is still possible.

The minimum pH allowing growth is 4, but again the limiting range for enterotoxin is higher, reports suggesting pHs below 5 will stop toxin formation. The minimum growth temperature is reported to be 7°C, but again a temperature between 9-10°C is reported to prevent toxin formation.

Of course in many foods the main control is likely to be the implementation of good hygiene measures during production handling and storage. This will limit the chances of foods becoming contaminated in the first place and should be a prerequisite of good food manufacturing.

Detection and enumeration

Most food producers use enumerative methods for staphylococci. The most common being that detailed in European and International Standards based on either Baird-Parker Agar (BPA) or Rabbit Plasma Fibrinogen Agar (RPFA).



Both of these are selective and differential agars on which staphylococci produce very typical looking colonies. It is usual to confirm typical growth on BPA using a coagulase test, or similar latex agglutination test showing the presence of the potentially toxigenic 'coagulase positive staphylococci'.

Commercial manufacturers have produced a range of other test systems based on automated techniques, immunoassays and even molecular polymerase chain reaction based tests, and if properly validated these could be used as an alternative to the reference methods.

Of course as the 'biologically active' agent is not the organism but the toxin, a number of commercial manufacturers have produced immunoassays to detect the toxins themselves rather than the organism. These methods can be very useful in testing foods implicated in outbreaks of food poisoning, as even if the food has been cooked and the organisms killed, the test kits can still detect the presence of a toxin.

Conclusions

The food poisoning staphylococci were first recognised well over a century ago, and we understand them well. We can use that understanding of their origins and suitable control measures to prevent them entering our foods and on occasions where they may enter, to control and prevent their growth.

We see relatively few outbreaks of food poisoning due to these organisms, however this is likely to be in some way an artefact of limited reporting. We must however keep horizon scanning, as there have been concerns over a specific group of staphylococci that cause hospital infections, and their possible role in foodborne illness.

This group are known as the Methicillin Resistant *Staphylococcus Aureus* (MRSA). They have been found on food animals and in raw meats destined for human consumption, and whilst they should be able to be controlled in the same way as other staphylococci, they could result in a much closer interest in the presence of staphylococci in foods in coming years.

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