An understanding of bacteriology for the non-bacteriologist

Bacteriology and an understanding of it is becoming more and more important in modern food production, processing and handling. This article will endeavour to put microbiology into everyday language.

The easiest way to view a bacterium is as a 'microscopic animal'. It can not be seen by the human eye, except with the assistance of a microscope. If we put bacteria in a chain, we would need some 25,000 bacteria to create a chain one inch long (or some 10,000 if the chain was one centimetre long).

Microscopic animals

If we look at bacteria as microscopic animals then an understanding of their properties gives us an interesting insight into aspects of microbiological control (see Table 1).

Given ideal conditions – plenty of food and water, the right temperature and an avoidance of build up of toxic waste products – bacteria can grow and multiply very quickly. Given ideal conditions certain bacteria can multiply every 10 minutes. Bacteria multiply by binary division and so every time they multiply their numbers double (see Table 2).

From Table 2 it can be seen that within 10 generations one bacterium can become 512, within 20 generations 524,288 and within 30 generations 536,871,088 bacteria are produced! Or, to put it another way, it takes just 31 generations for one bacterium to

Generation	Count	Generation	Count	Generation	Count
1	1	11	1,024	21	1,048,576
2	2	12	2,048	22	2,097,152
3	4	13	4,096	23	4,184,304
4	8	14	8,192	24	8,388,608
5	16	15	16,384	25	16,777,216
6	32	16	32,768	26	33,554,432
7	64	17	65,536	27	67,108,864
8	128	18	131,072	28	134,217,772
9	256	19	262,144	29	268,435,544
10	512	20	524,288	30	536,871,088
				31	1,073,742,176

Table 2. The dynamics of bacterial multiplication.

You might well say that bacteria die off. That is correct but a very small number are dying off relative to what is being generated. Let's say the life span of a bacterium is 10 generations (in reality it is probably longer) and let us look at the effects of moving from the 10th to the 20th generation.

By the time the 20th generation is produced, the 10th generation has died off so the amended figure for number of bacteria alive is 523,776. Not much difference when compared to 524,288!

Rate of bacterial multiplication is very much temperature dependent (Table 3) and so the importance of maintaining the cool chain when producing a whole variety of foods is critical. In this example E. coli grows and multiplies 36 times faster at 30°C than it does at 10°C!

Table 1. Properties of bacteria.

Property	Significance to bacteria	Significance in control
Eat	Food is any organic matter and only need very small amounts.	Keep surfaces and equipment clean as this removes the food source.
Drink	Drink is water but this may just be areas of dampness.	Keep surfaces and equipment dry as this removes the water source. Drying can be an important part of the cleaning process.
Breathe	Many bacteria require oxygen.	Remove oxygen eg vacuum packing, CAP, MAP etc to extend shelf-life.
Temperature	Bacteria grow and multiply faster at warmer temperatures. High temperatures lethal.	Refrigerate and keep product and room temperatures cool. Cooking, pasteurisation etc.
Movement	Can not walk, but many can swim in water films. Can 'ride in taxis'.	Focus on drying as part of the cleaning process. Any object can transfer bacteria eg. be careful not to move things from floor or drains to production surfaces.
Shelter	Any microscopic hole or crack can be a haven for thousands of bacteria.	Smooth, durable and impermeable surfaces. Avoid old, perished (cracked) rubber in equipment.

Several key groups

If we look at bacteria in general food microbiological terms they fall into several key groups and the most important ones are the spoilage organisms, the foodborne pathogens and the faecal indicators.

The spoilage organisms include bacteria such as pseudomonas, the lactic acid bacteria and, in the case of fruit and fruit juices, the yeasts. These organisms hasten the spoilage of foodstuffs, hence their name.

The foodborne pathogens are bacteria that can cause disease or food poisoning in man. Among these are salmonella, campylobacter, Listeria monocytogenes, Clostridium perfringens, E. coli O157 and

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Staphylococcus aureus. Needless to say, these want to be absent from the food we eat especially if the consumer is not going to cook the food before consumption.

However, we need to be realistic about this and for any food poisoning bacteria to cause food poisoning it needs to be consumed at levels above its infectious dose. For some bacteria, for example E. coli O157, this can be quite low, whereas for others it can be quite high.

Thus, when it comes to L. monocytogenes we have an intriguing situation either side of the Atlantic. The Europeans are slowly moving towards the previously held view of the Americans of zero tolerance, while the Americans are slowly moving towards the previously held European view that low levels are acceptable, for example 100cfus of Listeria monocytogenes per g of food!

The faecal indicators are bacteria that are present in faeces (human, animal, avian, reptilian, piscine and from insects) and when they are found in food they are indicative of some faecal contamination having occurred.

Their significance is that they are present at higher levels than faecally borne pathogens such as salmonella, E. coli O157 and campylobacter and therefore easier to detect and enumerate. If faecal indicators are found at high levels the probability of finding foodborne pathogens such as salmonella increases.

Bacterial testing is done on 10 or 25g of product. If we consider salmonella we test 25g of a product. If we get a 'negative' or, more precisely, a 'not detected' result it means that no salmonella were found in that sample. If we consider a tonne of an ingredient it will contain 40,000 of these 25g samples. So, if we had an ingredient that was only contaminated at 4,000 salmonella organisms per tonne then the probability is that if we tested one 25g sample it would be 'negative'. If we tested 10 samples there would be a pretty good chance that all 10 samples would be 'negative'.

This is on the basis that the test is capable of detecting one salmonella organism and that that organism is homogeneously dispersed in the ingredient. If either or both of these are not the case then the probability of detection is further reduced. For these reasons we should always be saying 'salmonella was not detected in the sample of ingredient tested' rather than 'we guarantee the sample to be free from salmonella' because on the basis of the test and sample size we can not give such a guarantee.

Temperature (°C)	Generation time (hours)
0	20
15	6.0
20	2.8
25	1.4
30	0.55

Table 3. The effect of temperature on generation time for E. coli.

Careful handling essential

In many ways testing is only as good as the samples taken. If we are taking hygiene swabs and we are careless in our handling of them and inadvertently touch the swab, the result will be the combined bacterial load from the surface tested and our dirty hand!

If we collect product samples and leave them on a windowsill in the warmth of the sunshine, don't be surprised if you get high bacterial counts! The trouble with bacteriology is people do not put it into context and try to overcomplicate its interpretation.

Hygiene swabs are a good example. Do we want to know whether a surface is bacteriologically clean or dirty or do we want to know whether there are 5,034 or 5,035 bacteria per cm^2?

The former is a much cheaper test. So, surely common sense says go for the former and test more areas or save some money, because all we want to know is whether that area is clean or not! ■

The future of food

Two great food events are being held in Edinburgh in April this year on the 22nd and 23rd of April. The first is a joint Scottish Food and Drink Federation, Institute of Food Science and Technology and Royal Environmental Health Institute of Scotland Symposium entitled The Future of Food – Can we strike the right balance? This conference will tackle a range of issues such as food security, feeding a growing global population, the impact of climate change and the potential role of GM food.

The second event is the Institute of Food Science & Technology Conference and AGM 2010 entitled Food Science and Technology: The Ethical Dimension, which will address some of the challenges facing food manufacturers, scientists and the consumer to produce and select food which is fair and healthy for the farmer, producer, consumer and the environment. Both conferences will be held at the George Hotel and are expected to provide delegates with an unique opportunity to take part in stimulating discussions and debate with food industry colleagues, growers, leading scientists, consumer bodies and policy makers.
www.ifst.org/upcoming_events