9 – Microbiology of water

Water has many key roles in the processing of carcases and joints and in the manufacturing of meat based products. These include;

- As an ingredient.
- For the cleaning of carcases.
- For the cleaning of equipment and the fabric of abattoirs, processing plants and their equipment. This can be as a vehicle for disinfectants or on its own as a final rinse solution.
- As a means of cooling, for example ice tanks and poultry counterflow spin chillers.
- As the vehicle for polyphosphates or basting solutions that are injected into meat.
- For the cleaning of operatives' hands.

With so many important uses, most of which have direct or indirect contact with product, it is important that our water should be of the highest quality possible.

Where the availability of high quality water is limited, water can be recycled.

Where two types of water are available it is important that the best water should be kept for the most hygiene sensitive roles and that recycled water is used for less sensitive roles, for example primary wash downs in dirty areas.

When we look at water quality this can be defined in several ways including microbiologically, chemically, oxygen carrying potential and solid matter content but in this article we will only consider the first of these.

Microbiologically, we want water that has an overall low bacterial load so that we are not adding spoilage bacteria to our product or the areas and equipment that we have just cleaned.

In today's world it is quite easy for a water supply to become contaminated by faecal material of animal or human (sewage) origin.

We can check for this by screening the water for bacteria that only have a faecal origin.

These organisms, because of this role, are often called 'faecal indicators'.

Water can be tested for several faecal indicators but the most common ones are E. coli, coliforms, Clostridium perfringens and faecal enterococci. The acceptable bacterial levels for potable (drinkable) water in the EU are shown in the table below.

When we are testing water samples we obviously want a result that reflects the status of the water we are using.

For this reason it is important that the water sample gets to the testing laboratory as soon as possible and that it is kept cool by holding it in a refrigerator and then in a Kool box during transportation. The water should also be collected in a special bottle that contains a chemical, such as sodium thiosulphate, that will neutralise disinfectants/chlorine.

This is because, otherwise, these chemicals would act for a lot longer than they normally do and the laboratory could then unintentionally generate very good bacteriological results!

The other important thing is that we want to know the status of the water and not any debris on the tap, so when collecting a water sample we must first of all clean and sanitise the end of the tap.

Then we should run the water for a minute or so before collecting our water sample.

When testing water samples we sometimes need to be a detective. For example, if the water coming into our plant is microbiologically acceptable and that coming out of the end of the hose is not, there must be a contamination point between the two.

If we then take the hose off the tap and test the tap water and its results are satisfactory our problem must be in the hose. If the results are not satisfactory there could be a decomposing rat in your header tank! ■

Acceptable bacterial levels for potable (drinkable) water in the EU.

Bacterium	EU standard
Total viable count at 22°C	<100 cfu per ml
Total viable count at 37°C	<10 cfu per ml
Coliforms	Absent in 100 ml
E. coli	Absent in 100 ml
Faecal enterococci	Absent in 100 ml
Clostridium perfringens	Absent in 20 or 100 ml

10 – Hygiene swabbing – how valid is it?

Have you ever stopped to ask how meaningful environmental or hygiene swabbing really is? It certainly is not scientifically accurate, but it can be a very good management tool to identify areas that have been inadequately cleaned.

This being the case, why pay more for an 'accurate' count when a simple 'Yes/No' or 'Dirty/Clean' result is all you need?

In other words, why not use the same spend to take two or three or even four times as many swabs or do the same number of swabs and save money?

Colony forming units count

Most laboratories give a count of cfus (colony forming units) per swab because to try and relate the count obtained to per cm^2 of surface is totally meaningless and misleading. This is for two reasons.

Firstly, the laboratory has no control over how accurately or thoroughly the area to be swabbed (usually 16 or 25cm^2) was swabbed and, secondly, the proportion of the bacterial population removed from a surface depends on the nature of the surface swabbed and the amount of pressure used to apply the swab to the surface.

At the end of the day, bearing in mind how quickly bacteria can multiply, all we need to know is whether an area swabbed was 'bacterially clean' or 'bacterially dirty'.

This being the case, what is the point of swabbing an area that is 'visibly dirty' because it will invariably be 'microbiologically dirty'!

Thus, before we even worry about hygiene swabbing we need to satisfy ourselves that our cleaning team are getting things 'visibly clean'. Then it all comes down to psychology. To get staff co-operation and to ensure the QA staff seek out dirty areas we need to develop a culture based on improving our hygiene or positivity and not one based on punishment or negativity if bad results are found.

Psychology comes into play when you are planning your swabbing schedule because if your cleaners know which areas you are going to test it is in their best interests to ensure those areas are thoroughly cleaned. This is often done at the expense of other areas!

I always remember going into a food plant in the 1990s where the new QA manager, who had just recently graduated, took great pleasure in showing me her swabbing schedule for the next month which she had put on the noticeboard in the staff canteen. It precisely defined where each swab was to be taken! She was proud that since she had started swabbing the results had been excellent! We do not want excellent swab results – we want results that will pinpoint shortfalls in the cleaning programme and process so we can improve the situation.

To do this there is one key word and that word is random.

- Where we test should be random (but concentrating on food contact areas).
- The day on which we test should be random.
- The time we test should be random (for example day and night shifts).

In essence, we need to have an approach under which testing can occur at any time and test anything. If we do this, then we should see an improving hygiene picture!

It is human nature to relax after having been examined. This also occurs with cleaning teams. So, why not test unannounced on two consecutive days or shifts? Often the second results are poorer!

Educate and motivate

Results are not state secrets! Use them to educate and motivate your cleaning, production and maintenance staff. Why not find a way of depicting your results graphically so everyone can see how things are progressing over time?

This can easily be done by giving each swab's results a numerical value and then calculating the mean. This can then be shown in a graph on which horizontal lines have been placed that represent 'good' and 'unacceptable' levels.

Obviously, much of what has been said here is just as applicable to ATP swabs. ■

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11 – Cooking meat

Cooking effectively destroys the bacterial population, such as E. coli, salmonella and listeria if all of the meat reaches the temperature and time specified in Table 1 (UK requirements).

Temperature (°C)	Time
60	45 minutes
65	10 minutes
70	2 minutes
75	30 seconds
80	6 seconds

Table 1. UK requirements.

USDA recommendations are based on core temperatures (see Table 2) and vary by product.

they spoilage organisms or causes of food poisoning need to be 'post cooking contaminants'.

Cooking in HACCP terminology is a critical control point (CCP), so we need to be aware of this and implement procedures to ideally avoid, but in practical terms minimise, post cooking recontamination.

Ideally, if we have enough production, we should operate ovens with two doors and these should be designed so both doors can not be opened. One door is for inputting product from the raw side and the other is for removing product on the cooked side.

Thus, before the product exiting doors can be opened a cooking cycle has to have been completed.

Product	Internal temperature (°C)	Time
Comminuted	62.22	5 minutes
	62.78	4 minutes
	63.33	3 minutes
	64.44	2 minutes
	66.11	1 minute
Beef joint	54.44	121 minutes
	62.78	<1 second

Table 2. USDA requirements.

Interestingly, the UK's requirements for core temperature are at least 70°C for two minutes which is significantly higher than USDA's requirements.

These temperature-time combinations are not adequate for controlling Clostridium botulinum in meat products with a high water content such as meats in gravy and meat soups.

Table 3 contains the Advisory Committee for Microbiological Safety of Foods recommendations.

Temperature (°C)	Time (minutes)
80	129
85	36
90	10

Table 3. Recommendations for Clostridium botulinum.

These requirements are much greater as they need to destroy the Clostridium botulinum spores.

The important thing is that at the time of effective cooking in the oven the meat has no bacterial population so any bacteria, be

This oven is then placed in a wall which divides raw from cooked in terms of environment, staff, equipment and products etc.

Often a reason for post cooking contamination is inadequate integrity in this division.

We can make use of microbiological testing to confirm this.

Obviously product testing will confirm the status of the cooked product and if required we can test a product before and after cooking to confirm the percentage kill of the cooking process.

We can also use such testing to confirm that the area the cooked product is coming into and is going to be handled in is microbiologically clean by means of swab testing.

Finally, it should be remembered that cooking has also destroyed the competitive normal flora on the meat so if a food poisoning pathogen gets on to the meat it will have a free run and high numbers may be achieved quite quickly. In this context, bacteria such as salmonella, E. coli O157 and Listeria monocytogenes are important. ■

12 – Bacteria's basic needs

If we have an insight into bacteria's basic needs we have the basics of a strategy of control as by removing their needs we can control them. You may think this approach is simplistic, but it is amazing how often this basic information is overlooked with adverse consequences.

Essential food source

Bacteria are basically microscopic animals so their needs are similar to those of any animal.

First of all, they need to eat. For bacteria, any bit of organic dirt is a food source and they will extract their nutrient needs. That splash of blood on the wall will be food for thousands of bacteria!

Think of Napoleon and Moscow – he did not get drawn into Moscow for a street fight, which he would probably have lost, but he destroyed all the standing and stored crops around Moscow, returned to France and let the Russian winter fight his battle for him. Bacteria are no different to Muscovites – remove their food supply and they will perish!

You might never have thought about cleaning in this way before, but surely all cleaning is the removal of the bacterial food supply?

Supply of water

Similarly, bacteria need to drink and any area of dampness is a water supply for thousands of bacteria. So, drying is also a way to slow down bacterial growth and so we raise conveyors after cleaning to facilitate the drying process.

If we leave the conveyors in situ there is a water film under them that favours bacterial growth and multiplication. This activity produces waste gases which can sometimes be detected by their smell when you lift up a conveyor on a Monday morning!

So, clean, dry areas are hostile areas when it comes to bacteria and their survival.

Most bacteria require air (oxygen) and the removal of this from poultry products by vacuum packing, MAP or CAP inhibits bacterial growth and multiplication.

That is why these processes are effective at extending or enhancing shelf-life.

Bacteria like to keep warm and grow and multiply faster at warm temperatures. Here again we can make use of this when it comes to managing the keeping quality of product as refrigeration, especially at <4°C, greatly inhibits bacterial growth and multiplication.

Bacteria, like most animals, can move but they do not have legs or wings – some have whip like appendages or flagella which propel them through a water film. In some situations they are moved by capillary action through such films. So, here is another benefit of a dry environment.

Mode of transport

Bacteria can be transferred from place to place on inanimate objects (taxis) known as fomites. Good examples of these are cloths, mops and brushes.

Anything that falls on the floor and is returned to the production surface effectively becomes a fomite as it transfers bacteria from the floor to the production surface and then invariably to the food that is being processed.

A key aspect of modern food hygiene management is to detect fomites and potential fomites and to remove them from the meat processing area.

Animals and bacteria like to be protected from adversities and, in the case of bacteria, this includes sunlight and disinfectants/sanitisers.

Any microscopic hole or crack, such as cracks in a perished washer or seal, will provide a safe haven that can harbour hundreds, if not more, of bacteria.

Management control

So, if management can provide rooms for meat processing with smooth, impermeable walls with no holes or cracks that are dry and clean and keep room temperatures low they are well on the way to controlling bacteria.

Conversely, wet, dirty, warm areas with rusting (damaged) metal, such as is found in wet vane coolers, is the perfect bacterial multiplication unit! ■

13 – Staphylococcus aureus

For most food poisoning occurrences it is the presence of the actual organism in the food that causes the food poisoning. For Staphylococcus aureus the situation is different as it is the presence of the enterotoxin that is produced by the organism and not the organism itself that causes the food poisoning.

However, the presence of Staphylococcus aureus can be regarded as a valuable indicator of possible enterotoxin presence. In addition, the presence of large numbers of Staphylococcus aureus on, say, cooked meat is indicative of poor management, that is, a failure to control contamination and/or temperature. This is the case whether or not enterotoxin is also present.

Many types

Staphylococci are Gram positive, catalase positive cocci (spherical shaped) bacteria and there are many types, including Staphylococcus aureus.

Somebody suffering from staphylococcal food poisoning usually shows signs within two to four hours of consuming the contaminated food and common signs include nausea, vomiting, and, occasionally diarrhoea.

Staphylococcal food poisoning is self-limiting and symptoms usually do not last more than 24 hours. Death rarely ensues but is occasionally seen in cases in the very young, the very old and those suffering a concurrent debilitating disease.

The enterotoxins of Staphylococcus aureus are a group of heat stable, water soluble single chain proteins and seven immunologically distinct ones are known. Enterotoxins A and D are the ones most commonly associated with food poisoning in man.

High prevalence in man

There is a high prevalence of staphyloccocus carriage in man and staphylococcal food poisoning is the only major kind of food poisoning associated with food handlers.

Staphylococcus aureus is an important pathogen of the skin and is present in lesions such as boils, infected cuts and blackheads but is also commonly found on healthy skin. It is also found in the nostrils, throat and in hair. Nasal carriage rates vary from 10-40% and food handlers should not have a dripping nose.

Staphylococcus is not only found in man – it commonly occurs in a variety of animals including pets and food producing species. Enterotoxin formation is more commonin human strains of Staphylococcus aureus.

Staphylococcus aureus has been known to colonise meat/poultry processing plants and especially defeathering equipment in the latter.

Staphylococcus aureus is invariably present on raw meat and human strains are more likely to be present when the meat is handled a lot.

Cold cooked meats (ham, roast beef and poultry) are common vehicles for staphylococcal food poisoning and outbreaks of food poisoning are often associated with catering.

Staphylococcus aureus is often found in low numbers (100 cfu per g) and these are of little consequence. When the levels are higher (10,000-100,000s cfu per g) they are regarded as unacceptable.

Key factors

The key factors associated with staphylococcal food poisoning are the popularity of cold meats in buffets, preparation of the meats well in advance of consumption, warm holding of meats such as burgers and the chef getting involved in the socialising and not concentrating on his duties!

Staphylococcal food poisoning attributable to vacuum packed sliced meat is relatively rare because of suppression of enterotoxin production in the packs because of low oxygen tension.

Production processes involving two cooking stages favour enterotoxin production as the toxin generation occurs between the main cooking and the reheating of the product. Occasional outbreaks have been associated with cooked shellfish. Staphylococcus aureus can be a real problem in salamis and similar products when the initial fermentation stage has been inadequate. ■

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14 – Bad practices

In this Meat Microbiology we are going to look at some of the bad practices that favour bacterial survival, growth and multiplication in the production area, which can be a precursor to product contamination.

Poor hand washing
Good hand washing takes time and must include thoroughly washing between all fingers and up the forearms. If this is not done, the person will take a bacterial load into the production area including bacteria he has picked up on his hands prior to when they should have been washed, for example, from outside or from the toilet area.

Poor hand drying
The practice of drying hands by wiping them on your overalls is bad practice because bacteria on the overalls will be immediately transferred to the person's hands.

Nose picking
Staff should never do this as it transfers bacteria straight from their nose to their fingers and then to the product. Amongst these bacteria can be harmful strains of Staphylococcus aureus.

Spitting
This should not occur in production areas because each spit contains millions of bacteria, including some strains of Staphylococcus aureus that can cause food poisoning. A real problem for a production area is to have a 'phantom spitter' as from time to time he will hit and contaminate product or production surfaces!

Leaning against production surfaces
By its very nature protective clothing will have become contaminated and this can include contamination from 'dirty' areas such as floors. This being the case, staff should never lean against or sit on production surfaces during breaks or, for example, between production runs.

Toilet habits
Staff should remove protective clothing before going into the toilet facilities. This is because protective trousers can have floor contact while staff are sitting on the toilet and coats can come into contact with the toilet itself!

Jewellery
Jewellery presents two risks. Firstly, stones can fall out and become foreign bodies and, secondly, wide rings such as signet rings can harbour a band of sweat under them that can contain high numbers of Staphylococcus aureus. From time to time, this can seep out and contaminate the production area/product. Ideally, no jewellery should be worn in production areas. If a concession has to be made it can be for stoneless, narrow-banded rings.

Haircuts
Some processing plants are in urban areas. In such situations staff should not be allowed to have a haircut in their lunch hour as when they return they will shed bits of short hair all afternoon and this could get on to product.

Pen sucking
The habit of pen sucking should be discouraged as it transfers bacteria, including Staphylococcus aureus, from the mouth to the pen, which in turn is transferred to the supervisor's hand and then on to product. ■

15 – Survival of campylobacter

Campylobacters are widespread in the environment and in the animals, birds and insects found there. Testament to this was the problem in the UK a few years ago when wild birds pecking milk bottle tops inoculated campylobacter into the milk, which then caused cases of campylobacter food poisoning in man.

For this vary reason a variety of foodstuffs, not just milk but also salads and vegetables, have been cited as causes of campylobacter food poisoning cases.

Campylobacters do not survive in extreme environments such as very low temperatures, very low humidities and acidic conditions. However, campylobacters must survive reasonably well or they would not constitute the problem that they do today.

It is thought that under adverse conditions campylobacters can go into a non-culturable, but viable, state (VBNCs –viable but non-culturable forms).

It is generally accepted that campylobacters do not grow at the chill temperatures at which most ready to eat and perishable foods are stored and often do not multiply up when temperature abuse has occurred.

However, a very important point is that the infective dose for man is low and so the survival of relatively few campylobacters represent a risk to man.

For this reason, any campylobacter control strategy should focus on elimination of the organism or at least a great reduction in numbers.

Another facet of the epidemiology of campylobacter food poisoning is cross-contamination of foods in production or in the kitchen.

The campylobacters associated with human food poisoning are thermotolerant or thermophilic and grow optimally at 37-42°C and do not survive very well at room temperature. However, they survive and grow well in birds (poultry) whose body temperature is 41-42°C, hence the importance of poultry meat in the epidemiology of human campylobacter food poisoning.

Campylobacters are able to survive in water for weeks at <10°C and in nature it is thought that they cycle between animals and contaminated water supplies, which may also infect domestic animals and contaminate crops.

Some examples of survival times and conditions are shown in the table below. ■

Source	Temperature	Survival time
Stream water	4°C	>4 months
Dairy slurry	March (Spring)	>20 days
Water biofilm	4°C	700 hours
Sheep faeces		<4 days
Sterile river water	5°C 15°C 25°C	>60 days 40-45 days <5 days
Ground chicken breast (sterile)	4°C	1-2 log reduction over 17 days
Beef strip loin	-18°C	>6 weeks
Unpasteurised milk	4°C	6-14 days
Raw chicken breast	2°C 10°C 20°C	>24 days >13 days >6 days
Cooked mince beef	2°C 10°C 20°C	>49 days >23 days >7 days
Pâté	2°C 10°C 20°C	>15days >6 days >1 day
Chicken juice	5°C	>50 days
Chicken skin	4°C -20°C	>7 days >14 days

Ref: C Bell & A Kyriakides in Campylobacter, 2009