Microbial update

Airborne micro-organisms

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In any food producing site there are a number of ways in which micro-organisms can be transferred around the environment and cause cross contamination of equipment and product.

Staff, ingredients/raw materials, and water will rank highly as transfer vectors. It is, however, easy to overlook the air and air movements as a way that microbial contamination can be transferred around manufacturing sites.

The atmosphere in food will contain airborne micro-organisms, some of which may be considered pathogens or be able to cause product spoilage.

Many types of bacteria and fungi survive well in the air, but consideration of the role of air in causing microbiological issues within foods is not high on many people's agenda and the routine monitoring of numbers of micro-organisms in the air around processing and packing lines is often a low priority.

In recent years the drive for fresher foods containing less preservatives and using lower processes but maintaining long shelf lives has seen the introduction of better designed well engineered air handling and ventilation systems in production areas.

These are often designed to include some form of filtration (HEPA) that will help with the exclusion of microbial contaminants, and in many cases air pressures will be balanced to prevent air movements from more contaminated to less contaminated areas.

Some sites/packing techniques will use equipment designed to handle and pack foods in an 'aseptic' environment, using localised air that has been filtered to exclude all microbial contaminants (usually seen in aseptic filling lines).

This does mean that the air is being seen to be a more important factor in the potential cause of microbial problems in foods and does require very careful consideration and in some cases sampling to check its quality.

EPA filter class E11 to EN 1822 suitable to restrict airborne microbiological contamination of food production processes. Illustration from Freudenberg Filtration Technologies.

The microbiology of the air

Many might consider the air an unwelcoming environment for micro-organisms, and in some ways it is. Obviously in the absence of moisture organisms cannot grow and increase in numbers. However, many organisms are great survivors and can withstand adverse conditions for a long time.

The spores of fungi are designed to be distributed by air flows, they survive well and can be a potent source of food spoilage incidents. Additionally, of course in some industries the pathogenic nature of airborne fungal spores is well known, a good example being 'farmer's lung' caused by the inhalation of aspergillus spores usually when handling contaminated grass crops on farms.

Likewise bacterial spores from genera such as bacillus and clostridium are well adapted to survive in adverse conditions.

Other non-spore forming organisms may be less well adapted, however, short term survival attached to dust particles or in aerosols will occur and is just as relevant to factory cross contamination issues.

Air in food factories

In order to fully understand the quality of air in production areas, and be able to take remedial action if it is required, it is necessary to be able to test the microbiological quality of the air.

Air sampling is generally undertaken for one of three main reasons:

- As a validation of the risk of product contamination from ambient air at a particular site (for example a filling head).
- As a validation and verification of the general level of the effectiveness of room air supply systems.
- As a validation and verification of the general level of the effectiveness of process air being introduced directly (for example for aeration or transport) or indirectly (for example from compressed air pneumatics) into food products.

Passive air sampling

In ambient air, the number of micro-organisms coming into contact with the food will depend on the concentration of micro-organisms in the air, the size of the particle they are being carried on (settling velocity), the surface area of the product exposed and also the time the product is exposed to the air.

This risk can be estimated by placing an opened Petri dish (or rehydrateable film), containing a suitable agar (referred to as a settle plate), at a point as close as possible to the product for a fixed sampling time.

Sedimentation techniques, referred to as passive air sampling, do not give an assessment of the number of micro-organisms in the air, only those that are of a sufficient size and weight to sediment to the surface in the exposure period.

The agar medium used should be chosen to enable the growth of whatever organisms are of concern, however, it should be ensured that items taken into the production area should not form a hazard to the food products.

Whilst settle plates will give an indication of the number of micro-organisms falling into product, they can only do this for a single time period and give no indication of the source of the airborne micro-organisms.

To understand the real risk to the product, the airflows in the processing area and the microbial sources need to be established.

Airflows can be assessed by smoke movements using smoke generators (as used in theatres) with a food safe smoke or, more sophisticatedly, with anemometers which record air direction and speed.

Airflows can be established under the likely range of environmental scenarios, for example doors open/closed, air supply/evaporative condensers on/off, machinery on/off. Known microbial sources in food processing include cleaning (highest risk), traywashers, weighing, bandsaws/slicers, people, vehicle movements and general factory operations.

The external factory environment may also be a source of micro-organisms, particularly yeasts and moulds, whose numbers and diversity may be seasonal.

It is possible to gain information on sources of micro-organisms using settle plates close to exposed product for all air flow, process and external environmental scenarios, though the use of airborne samplers may be more useful.

Active air sampling

The general level of micro-organisms in ambient air can be assessed by actively capturing airborne micro-organisms onto agar, into fluids or into a filter matrix.

The most commonly used active air samplers, which are purpose built for food factory use, work by drawing a set volume of air through a perforated (or 'sieve') frontplate onto the surface of a 'Rodac' plate or Petri dish over which micro-organisms impact. Alternatively, other samplers draw air over the surface of pre poured agar collection strips.

Both passive and active air sampling should be undertaken using non-selective growth media as micro-organisms present in aerosols are physiologically different from those in suspension for which selective growth media have been developed.

Once a knowledge base has been established about air flows, microbial sources and settlement into product, i.e. the process has been validated for airborne microbial contamination risk, it is rare to verify airborne microbial levels.

Rather the knowledge gained from this exercise can be used to predict when the product is at greatest risk from an airborne microbial challenge and whether additional control actions are required (for example no wet cleaning during production).

The microbiological validation of the ambient room air, filtration systems is useful in chilled food, clean fill and aseptic food operations, primarily by active air samplers.

Thermo Scientific air sampler.

Along with other parameters such as pressure drop across the filters, the filtration system's performance can be occasionally verified by air sampling.

Sampling process air

Process air is more of a microbiological risk to product than ambient air, as rather than via sedimentation, micro-organisms can be directly injected into the product.

The performance of process air supply systems should thus be microbiologically validated and verified for microbiologically sensitive products.

Process air can be sampled directly at the point of product contact by active air samplers, though the sampling of compressed air is more complex and is rarely undertaken in food factories.

The pressure of the compressed air must be reduced by a suitable in-line reducer to prevent damage to the sampler and to allow accurate sampling (relating to the velocity) through the sampler and thus impingement.

Compressed air can also be fed into a large sterile bag or chamber, from which the air can be subsequently sampled at a lower pressure.

Alternatively, a measure of the potential microbial contamination of compressed air can be obtained by swabbing the inside of the in-line water traps, i.e. anywhere in the compressed air line that micro-organisms could survive/grow following water condensation, though the compressed air should be switched off prior to sampling.

The level of micro-organisms enumerated from the verification of filter performance should be very low and will be established during the validation trials to allow target levels to be set.

Conclusions

The level of micro-organisms enumerated from ambient air will be very variable, however, and will be dependent on food product, process, factory design, production activities taking place at the sample time and sampling system used.

Total viable counts can range from 10^1-$10^4/m^3$ and yeasts and moulds can range from 10^1-$10^3/m^3$ in different food factories.

Even for ready-to-eat high risk environments, the count in the high risk area can be similar to that outside the factory – although of course the flora is likely to be very different!

Verification standards for ambient air are thus very difficult to universally set and can only be established for a particular factory and then only if 'normal' conditions (i.e. no cleaning being undertaken, no open doors, fans working, no excessive people movements, no non-typical process conditions etc) can be guaranteed.

Ambient air sampling is thus best for thoroughly understanding the transfer vectors and sources of micro-organisms that could lead to the airborne contamination of microbiologically sensitive products. ■

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