Microbial update packaging

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It is easy to overlook the impact of the development of food packaging on the types of safe food available to us. The pack is often seen as simply a convenient way to carry a food product around. But look more deeply into the types of packaging we now have in our retail stores and we see a huge range of different pack types that have been developed to do widely different things.

Shaped/coloured packs help in product marketing; sealed packs prevent cross contamination with foreign bodies and micro-organisms; packaging with particular barrier properties maintain certain gas atmospheres extending the life of food within; high temperature resistant packs allow thermal processes to be used to pasteurise or sterilise foods, increasing life and reducing food safety risks; and recently we have seen research into 'antimicrobial' packaging designed to prevent growth of, or even kill micro-organisms within packs.

Many food packs are highly researched and engineered to help deliver to the consumer high quality, nutritious and safe foods with a suitable shelf life. Although packaging provides essential protection, it has on occasion been implicated in causing microbiological issues due to being contaminated. Users of packs are well advised to consider this issue to gain confidence that packaging is an aid to food safety and not a risk.

Canning

Perhaps the first major development in packaging that had a real effect on microbiological food safety and shelf life was the use of the 'tin can'. The use of the heat processing of sealed containers to sterilise foods is thought to have been developed by Appert in the early 19th Century. He placed foods into glass jars, sealed them and then heated the jars in water, effectively sterilising their contents. In the UK, Peter Durrand had obtained a patent to preserve foods by sterilising within tin plated cans. His method would be viewed suspiciously today, but involved placing foods into cans, placing in cold water and bringing them to the boil, then opening the lid slightly, before resealing.

This was the first description of the use of the can. Interestingly, some evidence would suggest that Durrand learned of the technique from a French researcher, Philippe de Girard, who worked on the method previously. Durand sold his patent to Bryan Donkin who, after undertaking more research, set up the first food canning factory in the world, in London. The new canned products (predominantly meat) were rapidly taken up by the military and explorers, who needed a ready supply of high quality, long shelf life foods.

Microbiologically the can is simply a way to prevent foods becoming recontaminated after a heat process has killed contaminating micro-organisms. Cans have developed from large, thick heavy structures, to very small light ones.

Tin coated iron has been replaced by tin coated steel or aluminium, but the basis of the canning technique remains the same. Fill a container, seal it, apply a high temperature to kill microbial contaminants and cool. We now understand much more about the effects of heat on micro-organisms. In terms of safety, the major issue will surround the survival and growth of Clostridium botulinum, and those involved in canning will understand this issue well.

C. botulinum is an anaerobic sporeforming organism well suited to surviving heat processes (spores can survive moderate temperatures) and growing within the anaerobic environment of a can. This organism produces the most potent, toxic chemical known to man, botulinum toxin, a powerful neurotoxin that can kill through total muscle paralysis.

Cans containing foods which have a high acidity (a pH of below 4.5) can be processed at lower temperatures (effectively pasteurised), as any C. botulinum that may survive the heat process will be unable to grow as the pH will prevent it. Foods with a higher pH (>4.5), so called low acid foods, require a minimum process of 121°C for three minutes or equivalent (can centre temperature) to effectively give a 12 log reduction process to C. botulinum. This is usually known as an $F_0$3 process. Many low acid foods are given much higher heat processes than $F_0$3 in order to inactivate spoilage organisms that may have a higher heat resistance than C. botulinum. Interestingly there has been speculation that the growth of spoilage organisms in high acid (<pH4.5) foods could raise the pH during shelf life, allowing C. botulinum that was being controlled by the pH to grow, so suitable controls of spoilage flora could be considered a safety issue.

It is clear that even the long established, well used canning process that sounds so simple to apply, must be used with great care and only after proper scientific evaluation and validation of the actual technique that is to be applied to a particular food. There is no good alternative to the use of a food microbiologist/technologist to ensure that good controls are in place to prevent growth of C. botulinum.

One other issue has to be considered with products packed and processed in this way. Whilst a correctly processed product will be commercially sterile, the effects of previous microbiological growth may remain. Taints, enzymes and toxins produced by micro-organisms before the process may well remain after the process.

This can be a significant problem. Some heat stable microbial enzymes can cause sauces to become 'thin' due to starch breakdown – this does not tend to happen immediately, but some time into a product shelf life. From a food safety viewpoint, the growth of Staphylococcus aureus, before the process, may result in production of

Staphylococcal enterotoxins. These are highly heat stable, will not be inactivated by the canning process and can cause food poisoning.

Aseptic processing

In some ways this approach could be seen as very similar to canning, in that a sterile food is contained within a leakproof container which prevents its recontamination. However the way the process is applied and the container filled is very different. In the aseptic process the food material is heated in a flowing system outside of the container (usually at very high temperature for a very short time). This is then transported to an 'aseptic' filling area or machine where containers are formed and chemically sterilised, before being filled. Basically a heat sterilised product is filled into a chemically sterilised container within an aseptic zone (preventing airborne contamination from entering), and the container is then closed. Many of these systems tend to utilise what would appear to be cardboard block shaped packs, the complexity of the construction of the pack is impressive. The card gives strength and rigidity, on the inner side of this there will usually be a very thin metal film that acts as a gas barrier. This prevents gases such as oxygen getting into the product and affecting the product quality. Inside of this there will be a 'plastic' film, isolating the product, making the container watertight. The control of organisms is through simple heat processing of the product, and chemical decontamination of the container. Again understanding the chemistry (particularly the pH) of the product is critical to the setting of a correct heat process, and maintaining a safe product.

One interesting food spoilage problem that has affected aseptically produced fruit juice products come from the survival and growth of a very specific spoilage bacterium, Alicyclobacillus. This organism is a heat resistant thermophile (only grows at elevated temperatures). It can become established in fruit juice producing factories and survive some Ultra High Temperature (UHT) processes contaminating the product.

However, as the organism is a thermophile, spoilage will not become apparent unless the product is stored or transported to an area that has high ambient temperatures. Growth then occurs, producing a distinctive chemical taint.

Modifying microbial growth

Moving away from examples where the pack simply prevents microbial recontamination, to packs where we use scientific principles to actually modify which groups of microorganisms can grow, Modified Atmosphere Packing (MAP) is made up of two major types: the vacuum pack and the controlled atmosphere pack.

In the former, food is placed into a polymer bag, and all the air is withdrawn, leaving the polymer forming a tight film against the food. In the latter, foods are placed into polymer trays, the gas atmosphere within the tray is modified by the addition of a gas mixture of known composition, and the tray is sealed with a film. In modified atmospheres we acknowledge that the foods we are dealing with have a natural microflora; they are not sterile.

What we aim to do is modify how that flora grows. In many MAP packs we use an oxygen free environment to prevent the growth of aerobic bacteria (such as Pseudomonas spp.) and moulds. Other organisms can grow (lactic acid bacteria), but these grow more slowly, thus extending the shelf life of the food product. Of course, every change we make that affects the growth of a microflora, can have both positive and negative effects.

This change to an anaerobic condition will open up the risks of C. botulinum growth within these packs. In order to control this risk we have to employ particular heat processes, or ensure that the food is at a low pH or reduced water activity, or we limit its shelf life to 10 days or less.

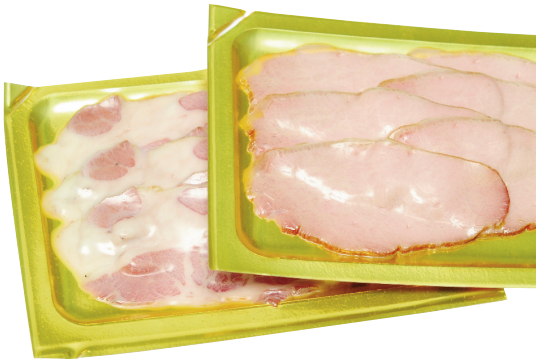
There is good guidance available to producers of MAP packed foods to help in the use of good controls. Of course in MAP packed chilled foods, the other risk that manufacturers must consider is from the growth of Listeria monocytogenes.

This organism is what microbiologists know as 'facultative', that is it can grow both with and without oxygen, so eliminating oxygen does not act as a control measure, and good handling and hygiene must be used during the manufacturing process

There is some interest in the use of packs containing high oxygen as microbial control systems. Oxygen is a highly toxic gas and as its concentration is increased it will have an antimicrobial effect. High oxygen is often used to improve the visual appearance in red meat packs, as it maintains the red colour.

However, there is now consideration as to its effects on campylobacter in raw chicken packs. Campylobacter is found contaminating a large proportion of raw chicken, and it is the biggest single cause of food poisoning in the UK and many other countries. It is, however, very sensitive to oxygen, with even the concentration present in normal air being inhibitory. The question is, if it were placed within a high concentration of oxygen, would the campylobacter die off, thus reducing risks to the consumer? Time and further research will give us the answer.

Although active packaging systems have been available since the 1970s, they are not widely used in the food and drink industry. Active packaging can be defined as the incorporation of an active system into packaging film or a container to maintain the quality or extend the shelf life of the product. Typical systems used include oxygen and carbon dioxide scavengers or emitters, moisture absorbers, ethylene scavengers, flavour and odour adsorbers and ethanol emitters.



The mechanism by which foods deteriorate needs to be understood before applying any type of active packaging solution. By considering the mechanisms it is often possible to apply different active packaging techniques to extend shelf life.

The term intelligent packaging is rather broad and can be defined in a number of different ways, in essence it informs the consumer of some aspect of the quality, nature or production history of the food.

For example, it can indicate whether its contents are warm enough or cold enough to eat or drink to maximum enjoyment, or whether they remain fit to eat. It can also inform of the conditions to which the food has been subject during its distribution and storage. Intelligent packaging can also assist with traceability, tracking and record keeping through the food supply chain from harvest and manufacture of food and packaging materials to point of sale and beyond.

Final comments

Microbiologically, food packaging does many things. It protects from external contamination, and it allows the development of very long shelf life nutritious and safe foods. It allows us to drastically alter the microbial ecology of a foodstuff, preventing the growth of unwanted organisms and encouraging the growth of others, helping extend shelf life.

However, we can only use these features if we have expert microbiological knowledge and understanding. Getting it wrong could have dire consequences, and anyone investigating changes in packaging, or how packs are processed, or even those considering changing product recipes without considering the effects on the process and pack must seek expert help and assistance.

In 1989 a canned hazelnut puree had a 'minor' recipe change, sugar was replaced with an artificial sweetener to produce a low sugar alternative. No change was made to the process used for the canned product. The result was the largest outbreak of botulism seen up to that time in the UK.

Packaging and associated processes give us good high quality foods, but the research and science behind these must never be forgotten and expert knowledge and assistance gained when designing such products. ■

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References are available from the author on request