Microbial update
modified atmosphere packed foods

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In the past fresh foods were packed in bags, boxes or packs containing 'air', with a general composition of 79% nitrogen, 20% oxygen and 1% carbon dioxide (plus some other rare gases).

More recently, however, consideration has been given to packing fresh foods in different gas atmospheres. The first use of this type of technology was in the mid 20th Century when elevated levels of carbon dioxide were used during the long distance transport of some bulk meats and fruits, to extend their shelf life.

More recently, modified atmospheres have found use in individual single packs of fresh products and are commonly seen in food retailers, although the consumer may, in some cases, never realise that what they buy is in a modified atmosphere.

The practice of MAP has a number of effects on both chemical and microbiological changes that occur in a food over its shelf life. Generally, any pack in which the gas atmosphere has been changed can be referred to as a Modified Atmosphere Pack (MAP), and Vacuum Packaged (VP) items also fall into this category.

Why change the atmosphere?

Most fresh foods still have biological and biochemical activities going on within them, these may be due to active enzymes that are present in the food, or due to the presence of micro-organisms within or on the food.

This article will primarily be concerned with the microbiological effects of MAP which involve the use of different atmospheres to alter the type of microflora (bacteria, yeasts, moulds) that are able to flourish on different food types. By changing the flora, it is possible to retain freshness within particular foods, thus extending the shelf life and giving consumers a better quality product for a longer period of time.

Needs of micro-organisms

In order to get a better understanding of the effects of MAP on foods, it is necessary to more fully understand a little about the different micro-organisms that may be present on those foods. Fresh foods such as chilled fresh and cooked meats, salads, sandwiches, and dairy products, will usually contain micro-organisms.

These organisms are naturally present and are usually quite harmless to consumers, they will however effect the freshness and shelf life of the product.

The micro-organism present on individual products will be of many different types. Some will not be able to grow, others may be able to grow quickly, whilst others develop more slowly. Their ability to grow will depend on a multitude of different factors such as the temperature of the food, its pH, its water activity but also on the type of gas conditions that surround the food.

Micro-organisms can be sub-divided depending on the type of gas condition that they prefer to grow within.

Considering Table 1, it is clear that in a food that contains a diverse mix of micro-organisms, the alteration of the gas atmosphere will affect which type of organism is able to grow.

Effects of different gases

● **Carbon dioxide**

Carbon dioxide will inhibit the growth of many aerobic bacteria and moulds. In general, the greater the concentration of carbon dioxide, the greater the inhibition and the longer the achievable shelf-life. Carbon dioxide is however absorbed by fats and water, therefore, many foods will absorb carbon dioxide. Excess levels of carbon dioxide in MAP can cause flavour tainting, drip loss and pack collapse. It is very important that there is a balance between the shelf-life of a product and the possible negative effects of higher concentrations of carbon dioxide. Many manufacturers using carbon dioxide to

Table 1. Affect of gas condition on different types of organisms.

Microbial grouping	Preferred gas condition	Examples of type of organism
Aerobic organisms	Needs oxygen to be able to grow. In the absence of oxygen, no growth is possible. However, oxygen is toxic to all organisms at high levels, aerobes usually thrive optimally at 20% oxygen.	Pseudomonas, many types of Bacillus spp. Many types of mould
Anaerobic organisms	Must have an absence of oxygen to be able to grow. Oxygen, even at low concentration can be toxic to these organisms.	Clostridium spp.
Facultative organisms	Can grow well either in the presence or absence of oxygen.	Salmonella, listeria, yeasts, lactic acid bacteria, members of the family Enterobacteriaceae
Microaerophilic organisms	Grow optimally in the presence of low levels of oxygen (below that present in atmospheric air)	Campylobacter

control microbial growth use a concentration of about 20%.

● **Nitrogen**
Nitrogen is an inert gas, it does not in itself inhibit microbial growth and is used simply to replace oxygen in MAP. It is used as a balance gas to make up the difference in a gas mixture and prevent the collapse of packs containing high moisture and fat containing foods, which can absorb gaseous carbon dioxide. In some dry foods it is used to replace oxygen to prevent oxygen rancidity.

● **Oxygen**
Oxygen is required for the growth of aerobic micro-organisms. Often MAP will be used to reduce or eliminate oxygen, thereby reducing the growth of aerobic organisms and increasing the long term quality and shelf life of foods. There are a few cases where increased oxygen levels are used in packs, these may, for example, be to maintain a 'fresh' colour in red meats, to maintain respiration in fresh vegetables, or inhibit growth of anaerobes if these are a problem in particular foods.

Specific effects

It is important to understand that MAP will never completely prevent the growth of micro-organisms in a population, it simply modifies the type of organism in the flora that is capable of growing.

So, as a simple example, if we prevent the growth of faster growing aerobic organisms by excluding oxygen from a pack, but allow the growth of slower growing facultative or anaerobic organisms, then the food should stay fresher for longer and have an extended shelf life.

MAP is not usually used as the sole method for microbial control, but used in combination with other inhibitory factors such as chilled storage or low water activity, to have a maximum effect.

Considering the effects of MAP on different microbial groups: moulds are generally inhibited in low oxygen conditions and at carbon dioxide concentrations greater than 10%, whilst yeasts can tolerate high levels of carbon dioxide but with a much reduced growth rate.

Lactic acid bacteria can tolerate high concentrations of carbon dioxide, but as this is reduced and oxygen concentration increases, they will be outcompeted in chilled foods by aerobes such as pseudomonas. Aerobically packed chilled proteinaceous foods are particularly susceptible to attack by Pseudomonas spp.

Removing oxygen from such packs will prevent the growth of this group, allowing growth of slower growing species, thus potentially keeping foods fresh over a longer shelf life.

MAP is not generally used to control the growth of pathogens. Salmonella, Escherichia coli and listeria, for example, are generally quite tolerant to changes in gas conditions and a normal low oxygen MAP of 80% nitrogen, 20% carbon dioxide will have little effect on them.

There is some limited evidence that the survival of campylobacter may be negatively affected by increased oxygen levels, as this organism is a microaerophile. However, one of the most important pathogen related risks to understand and control when using low oxygen MAP, is that associated with Clostridium botulinum.

Clostridium botulinum risk

Whenever microbiologists consider the use of low oxygen conditions in food packs, serious consideration has to be given to the risks from C. botulinum.

This organism is an anaerobe and its growth can result in the production of a neurotoxin within a food which, if consumed, can result in very severe long term illness and even death.

There is a type of C. botulinum which is able to grow under chilled conditions (psychrotrophic C. botulinum), and the risks of growth of this organism must be a serious consideration by any producer of chilled MAP food products.

Since the early 1990s, there have been a number of recommendations made by advisory groups within the UK, concerning effective ways of controlling C. botulinum in chilled MAP products.

Control factors include:

● The application of an in pack process of 90°C for 10 minutes (or equivalent heat process).

● A pH within the food (and all parts of the food) of 5 or less.

● A water activity within the food (and all parts of the food) of 0.97 or less (or a salt concentration of 3.5% or greater).

● A combination of preservation factors that can be shown by experimentation or modelling to prevent the growth of C. botulinum.

● If none of these conditions can be met, then the shelf life of the product at chilled temperatures (8°C or less) must be restricted to 10 days or lower. (Note this only relates to shelf life with respect to C. botulinum risk, other microbial growth may limit the life to less than 10 days, and this must be investigated by manufacturers).

It should be noted that under deep chill conditions (<3°C) the organism is not recognised as being able to grow and the shelf life of such products, with respect to the C. botulinum risk, can be extended considerably. However, it must be ensured that the temperature never reaches or exceeds 3°C.

Conclusions

MAP has developed to be a very effective tool, able to extend the freshness and shelf life of chilled food products. It has been proven over many years to be very safe and deliver high quality products to the consumer.

However, it is a tool that requires a very good understanding of microbiology and microbial ecology, as it relies on altering growth conditions of different microbial groups within a population. It is recommended that manufacturers wishing to investigate the use of MAP for their products talk with expert microbiologists and food technologists such as the team at Campden BRI, in order to establish critical controls for the procedure within their products.

Most manufacturers of these products have good knowledge of the issues involved, and this has allowed production and delivery of a very wide range of very safe and high quality foods products to consumers over many years. ■

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References

● Betts, G. D. and Betts, R. P. (2009). The manufacture of vacuum and modified atmosphere packed chilled foods: a code of practice (second edition). Campden BRI Guideline No.11. Campden BRI, Chipping Campden, Gloucestershire.

● FSA (2008). Food Standards Agency guidance on the safety and shelf life of vacuum and modified atmosphere packed chilled foods with respect to non-proteolytic Clostridium botulinum. July 2008. FSA website (www.food.gov.uk).