A practical look at some of the issues in meat packaging

Much of the quality of meat and further processed meat products is now defined by the packaging of the end product, including the atmosphere around the meat.

Ideally, packaging should delay spoilage by inhibiting bacterial activity, allow maturing to continue by not inhibiting enzyme activity, and improve tenderness, weight loss and maintain the colour of the meat. Thus, issues such as lipid oxidation, dehydration, discolouration and loss of sensory qualities all come into play.

Obviously there are numerous meat packaging systems, each with its own uses and attributes and, in recent years, more and more packaging has been undertaken at point of production rather than at point of sale.

This centralisation of packing brings with it benefits in terms of economies of scale, less wastage, less weight loss through moisture loss, better and more consistent quality control, reduced losses at point of sale and a better product being presented to the consumer. Extensions to shelf-life can be gained via vacuum packing or MAP (Modified Atmosphere Packing).

Checking the effectiveness of vacuum packaging.

Factors affecting freshness

Let us first consider those factors which influence a product's freshness and then we will consider the role of packaging in the management of these.

Meat products deteriorate because of discolouration, oxidative rancidity and microbial degradation and these occur in the sequence they are listed.

Colour is synonymous with freshness and is the most important issue at point of sale. Muscle colour is related to myoglobin content (see Table 1).

Deoxymyoglobin is purple in colour and predominates in the absence of oxygen, for example in vacuum packed meats. When such packs of meat are opened, oxygen is introduced and the deoxymyoglobin become oxymyoglobin which is red in colour.

Over time, oxymyoglobin reverts to myoglobin and exposure to air the oxymyoglobin is converted to metmyoglobin which is responsible for the brown discolouration associated with meat that is not suitable for sale.

Basically in deoxy- and oxymyoglobin the iron in the haemproteins is in the ferrous state (Fe^{++}), whereas in the metmyoglobin it is in the ferric state (Fe^{+++}) and it is oxygenation which converts the ferrous to the ferric form.

Storage of meat (pork loin sections) in carbon dioxide atmospheres of 1.0-4.0% allows discolouration to occur by the twelfth day of storage, but when carbon dioxide with no oxygen is used no discolouration occurs.

In cured meats nitrosylmyoglobin is formed and rapidly converts to metmyoglobin in the presence of oxygen.

Nitrosylmyoglobin is much more sensitive to light than myoglobin, which is why cured meats can quickly fade while on display. However, this effect is reduced by vacuum packing the cured meat.

Table 1. The myoglobin content of some key meats.

Meat	Myoglobin content (mg per g)
Poultry (chicken)	0.01
Pork	1.00-3.00
Beef	3.00-6.00

Lipid oxidation results in rancidity, off flavours and off odours and deterioration in the colour and texture properties of meat. Mechanical boning, mincing, restructuring and cooking all cause significant disruption of the cells in meat, which facilitates the generation of free radicals and propagation of oxidation. This results in the production of hydroperoxides, which breakdown into aldehydes, alcohols and ketones and contribute to the off flavours generated during storage.

Lipid oxidation

Lipid oxidation is not usually a limiting factor in conventional overwrapped trays as their air permeable films allow the odour volatiles to escape, but in modified atmosphere packages these volatile products are retained because of their impermeable films.

These volatiles are then detected by the

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Packaging provides information and displays the product.

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consumer when the pack is opened. Storage of meat in high oxygen atmospheres reduces shelf-life because of lipid oxidation. For example, malonaldehyde in beef products increases quicker in MAP more rapidly than in vacuum packs.

Cooked and pressure treated meats are more vulnerable to oxidation than are fresh meats. The rate of oxidation of lipids is influenced by light, local oxygen levels, high temperatures, catalysts and water activity and controlling these usually significantly reduces the extent of lipid oxidation.

With cooked meats in an anoxic packaging environment, lipid oxidation still occurs to a varying extent because of residual oxygen in the product and package. The residual oxygen content in MAP packs is often 0.5-2.0%.

The third way that meat can 'go off' is by microbial action. A whole host of factors can influence the microbial population on meat at processing and most microbial contamination occurs after slaughter with microbes from the animal's digestive tract and from the processing plant's environment.

Most packing materials for the overwrapping of meat are permeable to oxygen and carbon dioxide and, therefore, provide favourable conditions for bacterial growth. These conditions are particularly favourable for pseudomonas which is a common cause of meat going off.

Fortunately, vacuum packing and using high oxygen impermeable film can inhibit the growth of Pseudomonas but it will not affect the growth of another spoilage organism – lactic acid bacteria, formerly known as Lactobacillus.

The most common bacterial spoilage seen in vacuum packed, sliced, cooked, cured meats is the sweet/sour odour caused by lactic acid bacteria and some other bacteria. Problems such as a cheesy odour or a sulphide odour are caused by different bacteria.

The presence of moulds or yeasts, especially on the surfaces of dried meat, is often indicative of defective packaging.

Bacterial spoilage of meat usually require bacterial numbers of 10^7-10^8 per gram of meat.

Factors affecting the nature and development of the microbial flora in processed meat products during chilled storage are many and include nitrite concentration, salt concentration, water activity, product pH, the presence of oxygen and the permeability of the packaging film.

Modified atmosphere packaging with high carbon dioxide levels are effective at inhibiting the growth of bacteria such as salmonella, pseudomonas, staphylococcus and clostridia.

Now let us briefly reflect on some of the packaging options that are available.

Vacuum packing

Vacuum packing is commonly used for meat and meat products and it works by excluding air from the space around the meat in the pack, thereby maintaining an oxygen deficient environment in the pack.

We need to end up with <500ppm of oxygen in the atmosphere if we are to prevent the irreversible browning due to low levels of residual oxygen. The sooner the meat can be packed after skinning, etc the better.

One plus for vacuum packing is that any failure is easily seen by the visible air pockets! Unfortunately, many consider vacuum packing to be unsuitable for meats, especially red meats, destined for retail display because of the purple discolouration associated with the oxygen depletion and which many consumers regard as unacceptable. In addition, drip forms in vacuum packed products and this is unacceptable to most consumers.

There are four types of vacuum packages for meat:

- The heat shrinking of a flexible material around primal cuts.
- The use of a pre-formed plastic bag or pouch in an evacuation chamber.
- The use of pre-formed plastic trays to which, after filling, a film is placed and the atmosphere is extracted prior to sealing.
- Vacuum skin packaging.

In addition, a number of packaging systems exist for processed meats and these can incorporate shrinkage processes.

The sous vide method was developed in the 1970s and involves packaging the meat product in multi-layered laminated pouches, cooking in a water bath and then rapidly cooling the pack before storing it under refrigerated conditions.

This method is acclaimed because the food is said to be nutritionally and sensorially superior because the low oxygen tension inhibits chemical oxidation and

microbial activity and because the packaging prevents the loss by evaporation of volatiles associated with the product's flavour.

Canning is also a kind of vacuum packing that can be used for meat products.

Modified atmosphere packaging is a process in which the product is enclosed in high gas barrier materials and in which the atmosphere in the pack has been changed to slow microbial growth and enzymatic spoilage with the aim of extending the product's shelf-life.

Odour scavenging packaging.

MAP systems for fresh and processed meats usually use mixes of carbon dioxide, oxygen and/or nitrogen but may also contain carbon monoxide, nitrous oxide, argon, sulphur dioxide or ozone. In the EU packaging gases are regarded as additives.

Oxygen's main role is to maintain the red colour of the meat, but for extending shelf-life some oxygen removal is required.

Carbon dioxide is an inhibitor of microbial growth and Gram negative bacteria are particularly sensitive to this gas whose microbial inhibitory properties have been attributed to altering the permeability of meat cells, pH changes and the inhibition of enzymes. Some 26% or so of carbon dioxide in a gas mix gives the greatest inhibition of spoilage organisms and its inhibitory effects increase as temperature reduces.

Nitrogen is a cheap inert gas that has no colour or taste issues and is also chemically unreactive.

The most commonly used gas mix is 30% carbon dioxide, 70% nitrogen.

MAP gas composition

Generally the gas composition within a MAP pack has a big impact on the type and extent of spoilage that develops during storage. High oxygen content extends both microbiological and colour shelf-life, for example a 70% oxygen 30% carbon dioxide gas mix.

The optimum temperature for storing packaged meat is -1.5±0.5°C and at temperatures of 0, 2 or 5°C the storage life is some 70, 50 or 30% respectively of that at the optimum temperature.

Pathogens such as E. coli and salmonella can tolerate high carbon dioxide concentrations and so their management is dependent upon strict temperature control. Also, higher temperatures (>3°C) decrease the colour stability of meat because, at such temperatures, myoglobin is more easily oxidised to metmyoglobin.

For example with beef it is 2-5 times faster at 10°C than it is at 0°C.

Controlled atmosphere packaging differs in that the package atmosphere is altered at the outset but then maintained throughout the product's life.

Meat discolouration is prevented by excluding all oxygen from the pack. This technique requires special evacuation equipment and the use of gas impermeable packaging materials.

This approach can utilise active packaging which uses substances that absorb things like oxygen, moisture, carbon dioxide and flavours and odours and which can, among other things, release carbon dioxide, antioxidants and flavours.

The most common form of active packaging used in the meat industry utilises oxygen scavenging.

When selecting a packaging material for use with meat products various requirements need to be met and these are detailed in Table 2. ■

Table 2. Properties required of packaging used for meat products.

- Contains the product
- Food compatible
- Non-toxic
- Can cope with handling/distribution stresses
- Prevents physical damage to the meat
- Appropriate gas permeability
- Controls moisture loss/gain
- If needed, protects against effects of light
- Has antifogging properties
- If tampered with this should be evident
- Conforms to legislation
- Seal integrity
- Prevents microbial contamination
- Protects from taints and odours
- Sales/consumer appeal
- Easy to open
- Tolerant of storage temperatures
- Prevents dirt contamination
- Cost effective