TEMPERATURE'S EFFECT IN CAP AND MAP FOR THE MEAT PACKAGING PROCESS

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Abstract

The meat packaging process with the CAP and MAP methods is influenced by the high or low temperatures. The qulities of packaed meat (eg. colour) are influenced in the case of all types of tissues by the high temperatures the same thing being manifested in the case of bacterial spoilage.
Keywords: *packagings, CAP, MAP, temperature, storage life.*

Introduction

Preservative packagings for fresh meats should maintain acceptable appearance odour and flavour for product, while allowing the development of desirable characteristics associated with ageing, and retarding the onset of microbial spoilage. Such effects can be achieved by packaging meats under various atmospheres of oxygen, carbon dioxide, carbon monoxide and/or nitrogen. The atmosphere within a pack may alter during storage, because of reactions between components of the atmosphere and the product, and/or because of transmission of gases into or out of the pack through the packaging film. Packagings of that type are termed Modified Atmosphere Packs (MAP), which are distinguished from Controlled Atmosphere Packs (CAP) within which invariant atmospheres are maintained throughout the time of storage.

Both MAP and CAP can take various forms, depending on the type of meat that is packaged, the form of the meat, and the commercial uses for the product. Obviously, a commercial user of preservative packagings would usually seek the simplest, and presumably least expensive packaging that would give a storage life and organoleptic quality suitable to the trading envisaged for a particular product. Thus, the optimum packaging for a product can be decided only with knowledge of how the qualities of the particular meat are affected by the various atmospheres to which it might be exposed, and the conditions the packaged product will have to tolerate during commercial storage, distribution and display.

Experimental

➢ The effects of temperature on storage life

All changes that occur in chilled meat during storage are likely to be accelerated by increasing temperature. As most changes are deleterious, it follows that the optimum temperature for storing chilled meats is the minimum that can be maintained indefinitely without freezing the muscle tissue. In practice, that temperature is found to be 1.5, 0.5°C.

When red meats are displayed in aerobic atmospheres, discolouration rather than microbial spoilage is likely to limit the useful life of the product. The rate at which discolouration develops in muscle tissue exposed to air appears to increase linearly with temperature for all muscles, but the rate of increase differs between muscles. The rate of increase seems to be less for colour stable than for colour unstable muscles, as discolouration of the colour stable *longissimus dorsi* and the colour unstable *psoas major* muscles are reported to be, respectively, twice and five times as rapid at 10°C than at 0°C. The effect of temperature on the rate of discolouration of meat stored in modified atmospheres rich in oxygen does not appear to be well identified in the literature, but it seems likely that discolouration with increasing temperature accelerates much as for meat stored in air.

When meat is stored anaerobically, the colour stability of muscle tissue increases at first, and then declines. The initial increase of stability is probably related to the relatively rapid loss of respiratory activity, while the subsequent decrease in stability reflects the decay of metmyoglobin reduction activities. The rate at which colour stability degrades is reported to be twice as fast at 5°C and four times as fast at 10°C as at 0°C.

Rates of lipid oxidation in air and oxygen enriched atmospheres are apparently similar, but the effect of storage temperature on the rate of development of rancidity does not seem to have been established. Exudate losses are reported to be about 30% and 100% more, respectively, at 5°C and 10°C than at 0°C. The rate at which muscle tenderises is over twice as fast at 10C as at 0C.

Spoilage bacteria will grow on meat that is not frozen at temperatures down to 3°C under both aerobic and anaerobic conditions. Thus, storage at chiller temperatures can delay but not prevent the ultimate onset of microbial spoilage. Although the rates of growth of different species of spoilage bacteria differ considerably the rates of all increase rapidly with small increases in temperature above the optimum for storage of chilled meat. The proportional loss of storage life for the same increase in storage temperature is then broadly similar for all types of spoilage flora. Thus, it is found that the storage life of meat in any or no packaging at 0, 2 and 5°C is about 70, 50 and 30%, respectively, of the storage life that would be obtained for the product stored at 1.5°C.

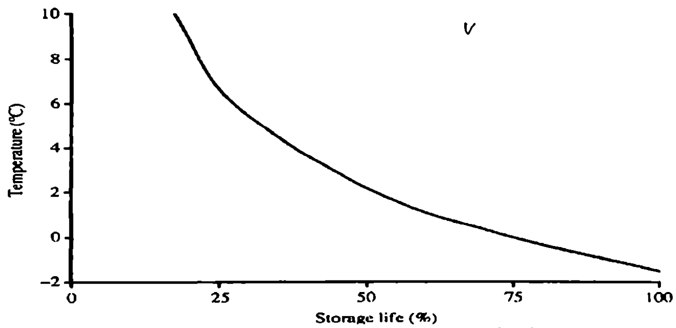

Fig.1: Effects of storage temperature on the storage life of chilled meat limited by microbial spoilage.

Results and Discussion

1. Modified atmosphere packaging (MAP) technology for meat products

Modified atmosphere packagings may be used for bulk or retail ready product. Several trays of retail ready product may be placed in a master pack which is filled with the modified atmosphere, or individual, sealed trays may contain the modified atmosphere. Modified atmospheres invariably contain substantial fractions of carbon dioxide to retard the growth of aerobic spoilage organisms. In addition, atmospheres used with red meats will usually contain a high concentration of oxygen to preserve the meat colour or the initial atmosphere may contain a small amount of carbon monoxide to impart a stable red colour to the product. An atmosphere may also contain a more or less substantial fractionof nitrogen, to prevent pack collapse.

The materials used to form modified atmosphere packs must provide a barrier to the exchange of gases between the pack and the ambient atmosphere. However, the gas barrier properties of the packaging materials differ for different types of packaging and differing commercial functions of the packs. Bulk and master packagings which are expected to contain product for only a day or two are often laminates composed of a strong material with limited gas barrier properties, such as nylon, and a sealable layer of a material such as polyethylene. Such materials may have nominal oxygen transmission rates of more than 100 cc/m2/24h/atm under stated conditions of humidity and temperature. However, films used for modified atmosphere packs usually have oxygen transmission rates between 10 and 100cc O2/m2/24h/atm, while packagings designed to contain product for the longest possible times are likely to be composed of materials with oxygen transmission rates less than 10 cc/m2/ 24/atm. Carbon dioxide, the essential component of any effective modified atmosphere for meat is highly soluble in both muscle and fat tissues. The solubility in muscle tissue decreases with decreasing pH and increasing temperature but, within the chill temperature range, solubility in fat increases with increasing temperatures.

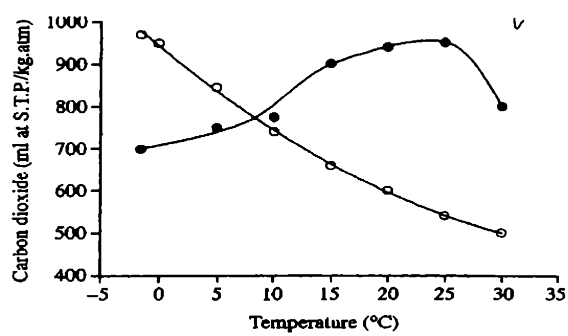

Fig.2: Effects of temperature on the solubility of carbon dioxide in normal pH muscle tissue and fat tissue of beef

Because of the dissolution of carbon dioxide in the product, the initial atmosphere in a pack should contain a higher concentration of carbon dioxide than the 20% that it is desirable to maintain after equilibration for maximum inhabitation of the aerobic spoilage bacteria. The smaller the volume of the atmosphere in relation to the product mass, the higher the carbon dioxide concentration needed in the input gas, and the greater the decrease in the volume of the atmosphere as carbon dioxide dissolves in the tissues after the pack is sealed.

Unlike carbon dioxide, the solubility of oxygen in muscle and fat tissues is low. However, oxygen is converted to carbon dioxide by the respiratory activities of both muscle tissue and bacteria. Although both gases are lost through packaging films when both are at concentrations above those of air. the carbon dioxide dissolved in tissue buffers decreases in carbon dioxide concentrations. Thus, with modified atmospheres rich in oxygen it is usually found that oxygen concentrations decline with time of storage, but that carbon dioxide concentrations alter little after the initial dissolution of the gas in the tissues. If packs with oxygen-rich atmospheres are to be stored for relatively long times, the volume of the pack atmosphere should be about three times the volume of the product, to avoid excessive decreases of oxygen concentrations.

The solubility of nitrogen in tissues is low, and the gas is metabolically inert. Thus, the only function of nitrogen in a pack atmosphere is to buffer against changes in the volume of the atmosphere that could lead to pack collapse, with crushing of the contained product. If carbon monoxide is included in a pack atmosphere it is at concentrations less than 1%. The gas will be removed from the pack atmospheres as it reacts rapidly and essentially irreversibly with myoglobin. The changes in pack atmosphere volumes as a result of the binding of carbon monoxide are trivial in comparison with the volume decreases arising from dissolution of carbon dioxide. Modified atmosphere packagings for bulk meats are usually intended only to enhance stability for short times during the distribution of product from slaughtering or carcass breaking facilities to retail packing facilities. Protection of the product from crushing by its being in a pillow-pack is often considered to be as important as any effects of the atmosphere on the colour or microbiological condition of the product.

Bulk packs are usually formed using equipment with two flattened tubes (snorkels) that are inserted into the mouth of each bag. Sprung guides at each side of the mouth prevent bunching. The mouth is held closed around the snorkels by padded jaws. Air is evacuated from the bag through the snorkels. The evacuation may be timed, or terminated when the pressure within the snorkels falls to a pre-set value. If evacuation is controlled by pressure and the snorkel orifices are not sealed by the bag collapsing around them, then the bag will collapse around the product and residual air in the pack will be minimised.

After evacuation, the pack is filled for a set time with the selected gas mixture. The evacuation and gassing cycle may be repeated if it is considered that the pack atmosphere may be excessively contaminated with residual air after a single cycle. When the bag has finally been filled with gas, the snorkels are withdrawn from between the closed pads, and the bag is heat sealed. With poultry meats the input gas may be a carbon dioxide/nitrogen mixture with the former gas at concentrations between 40 and 60%. However, 5% oxygen may be included in a mixture because of concerns about the possible growth of *Clostridium botulinum* if the atmosphere should become anaerobic. In fact, the inclusion of oxygen in the atmosphere will not prevent the growth of botulinum organisms, as anaerobic niches that could permit the growth of such organisms exist in any package of raw meat, irrespective of the surrounding atmospheres. For red meats the input gas would preferably be 70% oxygen and 30% carbon dioxide. However, nitrogen is often included in a mixture although that gas will serve no useful function when, as in these circumstances, the pack is flexible and the volume variable, and any undesirable pack collapse may be countered by simply increasing the volume of input gas.

Snorkel type equipment is also used for master packaging of retail ready product, with master packs being filled with the same gas mixtures that are used with bulk product. Retail ready product that is master packaged is usually in conventional, expanded polystyrene trays, which are overwrapped with a clinging film of oxygen permeability between 5.000 and 10.000 cc/m2/24h/atm. The trays usually contain plastic covered paper pads, to absorb exudate from the meat. Because collapse of the bag around the trays when the master pack bag is evacuated could easily lead to crushing of the trays, evacuation is usually timed.

Evacuation of the bag is then highly uncertain, as the amount of air in the bag when the mouth is closed around the snorkels can vary greatly. Moreover, the overwrapped trays will contain more or less large amounts of air that cannot be removed during evacuation. Consequently, the master pack atmospheres are diluted with air to varying extents.

Carbon dioxide and oxygen concentrations in master pack atmospheres are then often much below the concentrations optimal for preservation of the product. However, irrespective of the gas atmosphere, master packs provide mechanical protection for filled trays during their distribution from central cutting facilities to retail outlets.

Various types of equipment have been developed for preparing different forms of lidded trays that each contain a modified atmosphere. The atmosphere used for such trays is typically 60% oxygen, 30% carbon dioxide and 10% nitrogen. Storage/display lives of up to two weeks are often claimed for product in such trays. However, to attain such useful life, temperature during display as well as during storage must be well controlled, and the volume of the pack atmosphere must be large in relation to the amount of product in the pack. Control of product temperatures during display is often uncertain, and many retailers consider that small quantities of product in large packs are unattractive to consumers. Therefore, retailers often select modified atmosphere packs to provide an attractive packing in which a high concentration of oxygen, and thus an enhanced meat colour, are maintained for a limited time. Adequate display stability for the product is obtained by control of product temperatures near 1.5°C and by frequent, often daily delivery of freshly packaged product to retail outlets. The success of many current distribution systems for master packed product is achieved similarly.

The use of carbon monoxide in modified atmosphere is not permitted in most countries, because of the highly poisonous nature of that gas. Despite that, the risks to consumers from the presence of small amounts of carboxymyoglobin in raw meat appear to be small, and carbon monoxide is a common component of the modified atmospheres used with raw meats in Norway. As carboxymyoglobin confers a red colour on meat irrespective of the presence of oxygen, a modified atmosphere with carbon monoxide need contain no oxygen.

The input gas then typically contains 60% carbon dioxide and 40% nitrogen, with carbon monoxide at 0.3 to 0.5%. The major components of the input gas are at concentrations that will give the maximum carbon dioxide concentration after equilibration without the risk of pack collapse.

Thus, the carbon dioxide concentration can be maintained at levels above that required for maximum inhibition of aerobic spoilage organisms for relatively long times, without resort to volumes of atmosphere much greater than the volumes of product.

2. Controlled atmosphere packaging (CAP) for meat products

The only types of controlled atmosphere packagings currently used with raw meats are those in which an anaerobic atmosphere is maintained indefinitely. Controlled atmosphere packagings may be used for bulk product or items of irregular shape, such as whole lamb carcasses, or as master packs for retail-ready product. Controlled atmosphere packaging is not suitable for individual trays of retail-ready product because of the undesirable colour of anoxic meat, and because packaging materials that are impermeable to gases are mostly opaque. Readily available films that are essentially gas impermeable are laminates that incorporate a layer of aluminum foil, laminates with two layers of a metallised film, or laminates with unusually thick layers of plastics with high barrier properties.

Controlled atmospheres may be of carbon dioxide or nitrogen, or mixtures of the two gases. Nitrogen can provide an anaerobic atmosphere, but does not otherwise affect the muscle tissue or the microflora. Thus, the storage life of meats in a controlled atmosphere of nitrogen is similar to that of meats in vacuum pack; although in a gas impermeable, controlled atmosphere pack there is no oxidation of myoglobin in exudate or muscle tissue, which eventually become evident with meat in vacuum packs as the result of small quantities of oxygen permeating the packaging films.

Atmospheres of carbon dioxide have inhibitory effects on some organisms of the anaerobic spoilage flora, and can apparently retard the excessive tenderising of at least lamb. The inhibiting effects of carbon dioxide on the microflora appear to reduce rapidly with reducing concentrations of carbon dioxide in the atmosphere, so an atmosphere of or near 100% carbon dioxide is required if the storage stability of the product is to be substantially increased over that attainable with a nitrogen atmosphere. When an atmosphere rich in carbon dioxide is used, the high solubility of the gas in meat tissues must be taken into account. In an atmosphere of 100% carbon dioxide, meat will absorb approximately its own volume of the gas. Thus, the initial gas volume must exceed the required final volume by the volume of the enclosed meat.

The bag inflates in the evacuated hood, which ensures that no part of the bag collapses to entrap air. Some air is then admitted into the hood to give a low pressure which will collapse that bag around the product without crushing it. Thus, the volume of the bag is minimised before it is filled with gas. A pack may be flushed with the input gas one or more times before it is sealed. That relatively elaborate filling procedure is adopted to minimise the amount of residual oxygen in the pack. Even so, residual oxygen concentrations after pack sealing are usually about 100ppm. Snorkel equipment without a hood and even tray gassing equipment have been used, at least experimentally, for the production of controlled atmosphere packs. The residual oxygen in such packs is apparently often about 1%, which can have grossly adverse affects upon the colour of red meats. Even 100 ppm of oxygen can result in discolouration of product. However, in those latter circumstances discolouration is usually transient, as the metmyoglobin is reduced to myoglobin, usually within four days, as anoxic conditions are established and maintained. Various studies have been conducted to determine if oxygen scavengers might be used to prevent permanent discolouration of red meats in atmospheres with initial concentration about 1%, or transient discolouration of meats in atmospheres with very low concentrations of residual oxygen. Although some success with the atmospheres of the former type have been reported, the general utility of such an approach must be doubted because the muscle tissue itself acts as a very efficient oxygen scavenger.

Table 2: Half life of oxygen in packs containing 4L of atmospheres with < 1% oxygen when packs contained either four trays of ground beef or 32 oxygen scavengers each with a capacity of 200 mlg oxygen (Gill and McGinnis, 1995).

Temperature, °C	O_2 half life, h	
	With meat	With O_2 scavengers
- 1.5	4.7	0.6
0	3.8	0.6
2	2.9	0.5
5	1.4	0.5
10	1.6	0.5

Conclusions

Modified atmosphere packagings of various types have been used with mixed results in central cutting operations, most successful operations now rely on the frequent preparation of retail packs, with frequent and speedy delivery of product held at temperatures near the optimum for chilled meat rather than the preservative capabilities of modified atmospheres. Although retail preparation of product at slaughtering plants is increasing, particularly with poultry, the need for frequent and speedy delivery limits the area of distribution.

Thus, for the largest plants from which product is widely distributed preparation of retail product is a minor activity at most. A general conflation of slaughtering with preparation of retail-ready product at a few large plants would seem to be practicable only if the useful life of retailready product reliably exceeds the storage and display times usual in current commercial practice.

Despite the commercial advantages of, and the trivial risks associated with, the use of carbon monoxide, it is unlikely that many countries will sanction meat being treated with a recognised poison. A trend towards increasing use of controlled atmosphere packaging for retail ready product might then be anticipated. However, the complexities of meat trading are likely to ensure that such a trend develops only slowly.

Although controlled atmosphere packaging could be used for continental distribution of retail-ready meat, it is unlikely to be used for global distribution of such product. Storage life would not necessarily constrain global distribution but the low packing density of retail packed product as compared with bulk product could render shipment of meat by sea uneconomical.

Thus, controlled atmosphere packing is unlikely to replace vacuum packing in trading of chilled meats to distant markets, unless there is a move to retail portioning but not retail packaging at exporting plants. Otherwise, use of controlled atmosphere packing for trading meat over long distances is likely to remain restricted to products that cannot be successfully vacuum packaged, such as whole lamb carcasses.

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