Modified atmosphere

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Modified atmosphere is the practice of modifying the composition of the internal atmosphere of a package (commonly food packages, drugs, etc.) in order to improve the shelf life.

The modification process often tries to lower the amount of oxygen (O_2), moving it from 20.9% to 0%, in order to slow down the growth of aerobic organisms and the speed of oxidation reactions. The removed oxygen can be replaced with nitrogen (N_2), commonly acknowledged as an inert gas, or carbon dioxide (CO_2), which can lower the pH or inhibit the growth of bacteria. Carbon monoxide can be used for preserving the red color of meat.

Re-balancing of gases inside the packaging can be achieved using active techniques such as gas flushing and compensated vacuum or passively by designing "breathable" films known as equilibrium modified atmosphere packaging (EMAP). Packets containing scavengers may be used.

Testing the atmosphere in a plastic bag of carrots

Contents

Scientific terms

- MAP = Modified atmosphere packaging
- EMAP = Equilibrium modified atmosphere packaging
- MA/MH = Modified atmosphere/modified humidity packaging

History

Controlled Atmosphere Storage (CAS) was used from the 1930s when ships transporting fruits had high levels of CO_2 in their holding rooms, thus increasing the shelf-life of the product. In the 1970s MA packages reached the stores when bacon and fish were sold in retail packs in Mexico. Since then development has been continuous and interest in MAP has grown due to consumer demand. This has led to advances, for example in the design and manufacturing of Bacon films. New techniques have been designed, such as the use of anti-fogging layer to improve product visibility. From MAP a new packaging technique, EMAP, has been developed.

Products

The three major commodity types are fruits and vegetables, meat and meat products, and seafood. Many products such as red meat, seafood, minimally processed fruits and vegetables, pasta, cheese, bakery goods, poultry, cooked and cured meats, ready meals and dried foods are packaged under MA. It has been estimated that 25-40% of all fresh produce harvested will not reach the consumers table, due to spoilage and mishandling that occurs during distribution.

Modified Atmosphere Packaging (MAP)

Modified Atmosphere Packaging (MAP) is a technique used for prolonging the shelf-life of fresh or minimally processed foods. In this preservation technique the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. It is the shelf-life of perishable products like meat, fish, fruits and vegetables that will be prolonged with MAP since it slows the natural deterioration of the product. MAP is used with various types of products. The mixture of gases in the package depends on the type of product, packaging materials and storage temperature.

Meat, fish and cheese are non-respiring products needing very low gas permeability films and so-called high barrier films are used. The initial flushed gas-mixture will be maintained inside the MA package. Conversely, fruits and vegetables are respiring products where the interaction of the packaging material with the product is important and so low barrier or so-called high permeability films are used for these. So long as the permeability (for O_2 and CO_2) of the packaging film is adapted to the product's level of respiration, an equilibrium modified atmosphere will be established in the package and the shelf-life of the product will increase.

Equilibrium modified atmosphere packaging (EMAP)

Among fresh-cut produce Equilibrium Modified Atmosphere Packaging (EMAP) is the most commonly used packaging technology. When packaging vegetables and fruits the gas atmosphere of package is not air (O_2 21%; CO_2 0.038%; N_2 78%) but consists usually of a lowered level of O_2 and a heightened level of CO_2. This kind of package slows down the normal respiration of the product to prolong its shelf-life. Of course there are other factors, like the size of the product, severity of preparation, maturity of the product and type of tissue that have an effect to the shelf-life of EMA packaged produce.

Technology

Two techniques are used in the industry to pack vegetables. Namely gas-flushing and compensated vacuum. In gas-flushing the desired gas mixture is instilled in quantity into the packaging, pushing out the air, whereas in compensated vacuum the air is removed and the desired gas mixture then instilled. The label "packaged in a protective atmosphere" can refer to either of these. An example of a gas mixture used for non-vegetable packaged food (such as crisps) is 99.9% nitrogen gas, which is inert at the temperatures and pressures to which the packaging is subjected.

Gases

The atmosphere in an MA package consists of N_2, O_2, CO_2. It is the altered ratio of these gases that prolongs shelf life. Each food product has its own ideal gas mixture to ensure the longest shelf life possible. For example, by reducing the O_2-level and increasing the CO_2-level, ripening of fruits and vegetables can be delayed, respiration and ethylene production rates can be reduced, softening can be retarded and various compositional changes associated with ripening can be slowed down.

Oxygen helps to keep the fresh and natural color of food products, prevents the growth of anaerobic bacteria (present in certain types of fish and vegetables) and allows fresh fruit and vegetables to breathe. In the case of fruit and vegetables, the absence of O_2 can lead to anaerobic respiration in the package which accelerates senescence and spoilage. Levels of O_2 that are too high do not retard respiration significantly and it is around 12% of O_2 where the respiration rate starts to decrease. So oxygen is used at low levels (3-5%) for positive effect. When packaging meat and fish, for example, the high CO_2-levels are effective bacterial and fungal growth inhibitors. In the case of vegetables and fruits, CO_2 is not a major factor since CO_2-levels above 10% are needed to suppress fungal growth significantly. Unfortunately higher levels than 10% of CO_2 are working phytotoxic for fruit & vegetables. Nitrogen, for example, is used as a filler gas since it neither encourages nor discourages bacterial growth and it prevents the oxidative rancidity caused by the presence of oxygen in packaged snacks and dried products.

In recent years, there has been debate regarding the use of carbon monoxide (CO) in the packaging of red meat. While no risk was found in the use of low levels of CO, the fact that CO maintains the color of the meat, and can hide visual evidence of spoilage, was raised. The European Food Information Council (EFIC) released a report (http://ec.europa.eu/food/fs/sc/scf/out112_en.pdf) in 2001 reviewing the data.

Packaging Films

When selecting packaging films (web substrates) for EMAP of fruits and vegetables the main characteristics to consider are gas permeability, water vapour transmission rate, mechanical properties, transparency, type of package and sealing reliability. Traditionally used packaging films like LDPE (low-density polyethylene), PVC (polyvinyl chloride), EVA (ethylene-vinyl acetate) and OPP (oriented polypropylene) are not permeable enough for highly respiring products like fresh-cut produce, mushrooms and broccoli. As fruits and vegetables are respiring products, there is a need to transmit gases through the film. Films designed with these properties are called permeable films. Other films, called barrier films, are designed to *prevent* the exchange of gases and are mainly used with non-respiring products like meat and fish.

EMAP films developed to control the humidity level as well as the gas composition in the sealed package are beneficial for the prolonged storage of fresh fruits, vegetables and herbs that are sensitive to moisture. These films are commonly referred to as modified atmosphere/modified humidity packaging (MA/MH)films.

Quality assurance of MAP packages

Although Modified Atmosphere Packaging is a well-established process, it is a good practice to maintain tight quality assurance through package testing. Incorrect oxygen levels, empty gas cylinders and bad sealing bars can cause imprecise gas blends and poor package seals that can result in product spoilage. Routine package testing with headspace gas analysers, on-line gas analysers and leak detectors assures package quality, and hence helps to maintain shelf life.

Quality assurance: MAP analysers

There exist a number of analysers on the market for Modified Atmosphere Packaging to verify the gas mix is correct and ensure that the seal is not leaking. Both units built into packaging systems and handheld analysers can be used.

See also

- Active packaging
- Cold chain
- Modified atmosphere/modified humidity packaging
- Permeation
- Shelf life

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