re~fresh Technical Information - Modified Atmosphere Packaging Of Fresh Produce

Ready to eat whole, chopped, peeled, sliced, wedged or shredded fruit, vegetables and herbs can now stay fresher longer and travel further afield - in modified atmosphere packaging (MAP).

MAP is an effective method for prolonging the shelf-life of fresh and minimally processed produce - making it ideal for long haul transport, exporters, the hospitality trade and retail packaging. Because MAP enables processors to extend shelf-life without using chemicals it is also ideal for the packaging of organic produce.

MAP for the packaging of fresh fruit and vegetables differs markedly from that designed for meat, fish, poultry and bakery goods in that produce is still "alive" and respiring. Traditional gas flushed, barrier MAP packs used in the meat industry are unsuitable for the produce industry. The films typically used in the produce industry are selectively breathable films that offer high clarity, good sealing, and anti-fog properties.

MAP technology is certainly not new and was pioneered in Europe in the 1970's. Bruce Church Inc introduced fresh-cut salads on a retail level in the US. In 1966 the firm, then a 40-year-old Salinas, California produce company, acquired Trans Fresh who were experimenting with controlled and modified atmosphere packaging. Twelve years later Bruce Church created a new division, Red Coach Foods, which merged Trans Fresh's MAP technology with Bruce Church's lettuce, carrots and other packaged pre-cut produce for fast food restaurants. In 1981 Red Coach developed the first salad package for retail which, with the limited technology available at the time, provided a minimal shelf-life of less than seven days.

Since those early days the fresh-cuts market, along with the MAP market, has increased significantly. In 1994 the fresh-cut market in the US was worth US$5.2 billion, and by 2000 it had increased to US$19 billion. Fresh cuts now make up 10% of total produce sales in this market with packaged salads alone now topping US$1.8 billion per annum.

How does MAP work?

In a gas tight container, living vegetable material will modify the atmosphere due to

Other products in this category

- Hydrangea Liners
- re~fresh Ready-To-Use Life Extension Packaging for the Food Service Trade
- Cut Flowers
- Fruit
- Prepared Salads
- Vegetables

respiratory O2 uptake and CO2 output. Consequently, in packs of low permeability, anaerobic conditions will soon prevail and cause off odours and off flavours (Figure 1). With highly permeable packaging materials, the in-pack atmosphere will be similar to that of the external atmosphere composition, and respiration will not be reduced (Figure 2). In a properly designed MAP pack equilibrium concentrations of O2 and CO2 become established so that the rates of gas transmission through the packaging material equals the produce respiration rate (Figure 3). By correctly manipulating the amount of O2 and CO2 within the packaging, MAP enables the produce to live longer by delaying respiration, ripening and ethylene production. This in turn reduces enzymic browning, retards textural softening, preserves vitamins and extends the overall freshness of the packaged produce

MAP films must be specifically designed to match the handling conditions, ethylene sensitivity and respiration rate of the produce to be packaged, as each type and variety of produce has unique physical and biological characteristics that will require different film structures. The design of a MAP package is carried out in several stages. The first involves testing of the intended produce to ascertain its respiration rate (Table 1), respiration coefficient, anaerobic break point (the level of O2, under which, anaerobic respiration will prevail), ethylene production and sensitivity and optimum MAP environment.

Class	**Respiration Rate (mg / kg / hr)**	**Commodities**
Very Low	Below 10	Onion
Low	10-20	Cabbage, tomato
Moderate	20-40	Carrot, celery
High	40-70	Lettuce, radish
Very High	70-100	Spinach, bean
Extremely High	Above 100	Broccoli, pea

Table 1: Relative Respiration Rates

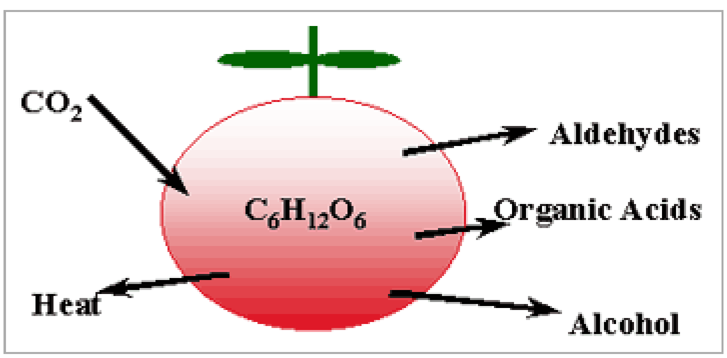

Figure 1: Anaerobic Respriation

Under anaerobic conditions (less than approximately 2% O2) produce converts stored sugars into energy via the glycolytic pathway as follows:

C6H12O6 ----> CO2 + Alcohol + Aldehydes + Organic Acids

One mole of sugar only produces two moles of ATP (64kJ total energy) and only 5% of the heat energy given off during aerobic respiration. This reaction is a fermentative reaction and is responsible for the off flavours and odours that result from anaerobic respiration.

Vacuum packing of fruit and vegetables causes these undesirable reactions but is often used as people mistakenly believe vacuum packed product is “fresher” and because browning reactions do not occur as rapidly to spoil the aesthetic quality of the product.

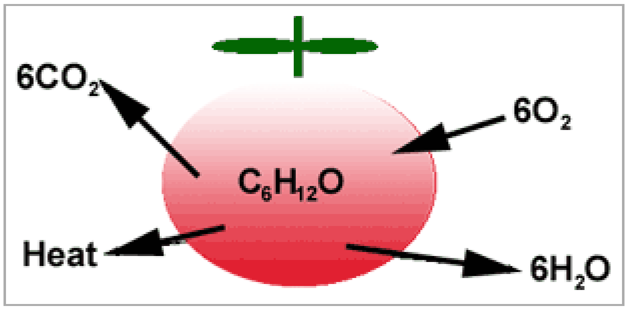

Figure 2: Aerobic Respiration

Under normal aerobic conditions produce converts stored sugars into energy with the following reaction pathway via the Krebs Cycle:

C6H12O6 + 6O2 -> 6CO2 + 6H2O + Energy

One mole of sugar produces 36 moles of ATP, each of which posses 32kJ of energy (1152kJ total).

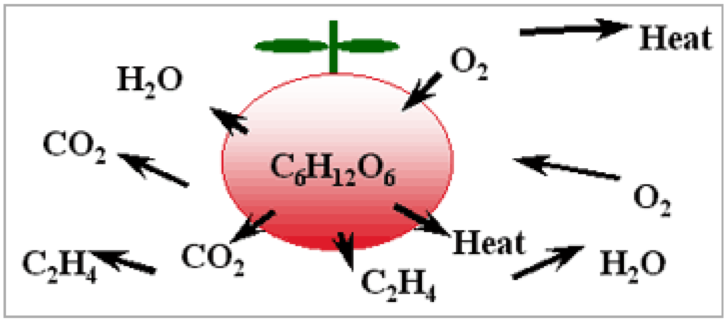

Figure 3: MAP in Action

Under the correct modified atmosphere conditions there is less O2 available for the oxidation of the sugars into energy which therefore slows down the rate of substrate depletion. This in turn leads to a longer shelf life for the product.

Modified atmospheres within a package can be established via active or passive modification or a combination of the two. If commodity characteristics are properly matched to film permeability characteristics, an appropriate atmosphere will passively evolve within a sealed package as a result of the consumption of O2 and the production of CO2 through respiration. In order to achieve and maintain a satisfactory atmosphere within the package, the gas permeability's of the selected film must be such that they allow O2 to enter the package at a rate offset by the consumption of O2 by the produce. CO2 must be vented from the package to offset the production of CO2 by the produce.

In active modification the atmosphere is established by pulling a slight vacuum and replacing the atmosphere of the package with the desired gas mixture from gas metering equipment. Additionally, absorbers may be included in the package to scavenge O2, CO2, or C2H4 to control the concentrations of these gases.

FACTORS AFFECTING MAP

Resistance and diffusion:

Movement of O2, CO2, and C2H4 in produce tissues is carried out by the diffusion of the gas molecules under a concentration gradient. O2 in the environment immediately surrounding the external surface of the tissue diffuses in the gas phase through the skin and into the flesh; it then diffuses from the flesh into the cellular solution or sap from where it diffuses in solution within the cell to the area for consumption. Different commodities have different amounts of internal air space (potatoes 1-2%, tomatoes 15-20%, apples 25-30%). A limited amount of air space leads to increases in resistance to gas diffusion. This affects the atmospheres that can be used for MAP, as products with high resistance to diffusion will become anaerobic in the centre if the outside air changes too radically.

Respiration rate:

Respiration in plants is the oxidative breakdown of starch, sugars, and organic acids to simpler molecules including CO2 and H2O with a concurrent production of energy (Figure 2). Some of this energy is released as heat and some as metabolic energy. One of the primary effects of MAP is a lower rate of respiration, which reduces the rate of substrate depletion. The respiration rate is tested in a sealed respiration cell of known volume, with a known volume and mass of produce. The atmosphere inside the cell is tested over time and from this information the respiration rates of both O2 use and CO2 evolution can be calculated. These are then averaged to give the overall respiration rate for the modeling calculations.

Ethylene production and sensitivity:

Ethylene (C2H4) is a natural plant hormone and plays a central role in the initiation of ripening, and is physiologically active in trace amounts (0.1ppm). O2 is required for C2H4 action and the binding of C2H4 to the receptor site is impeded when the O2 concentration is lowered below about 8%. C2H4 production is reduced by about half at O2 levels of around 2.5%. This low O2 retards produce ripening by inhibiting both the production and action of C2H4.

Optimum temperature:

Metabolic processes such as respiration and ripening rates are sensitive to temperature. Biological reactions generally increase two to three-fold for every 10°C rise in temperature, therefore temperature control is vitally important in order for a MAP system to work effectively. Understanding the optimum storage temperature is critical to the success of any MAP system as temperature outside the optimum for each product can limit potential shelf-life. (Figure 4) Film permeability also increases as temperature increases, with CO2 permeability responding more than O2 permeability. This implies that a film that is appropriate for MAP at one temperature may not be appropriate at other temperatures. This once again reinforces the importance of careful temperature management for package produce.

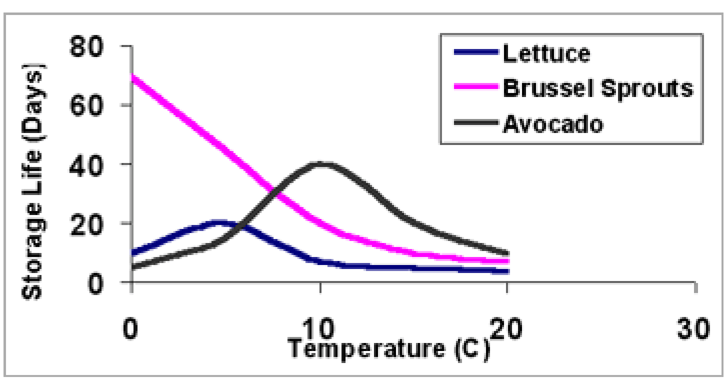

Figure 4: Temperature Effects

Optimum relative humidity (RH):

Low RH can increase transpiration damage and lead to desiccation, increased respiration, and ultimately an unmarketable product. One serious problem associated with high in-package humidity is condensation on the film that is driven by temperature fluctuations. The amount of condensate formed is related to the difference in temperature inside and outside the package, the void volume of the package and, to some extent the nature of the polymer film.

Optimum O2 and CO2 concentration:

An optimum atmosphere should minimise respiration, and hence increase shelf-life (Figure 5), without danger of metabolic damage. Since atmospheres within a package may fluctuate slightly the practical "optimal" atmosphere should be one that is not too close to an injurious level.

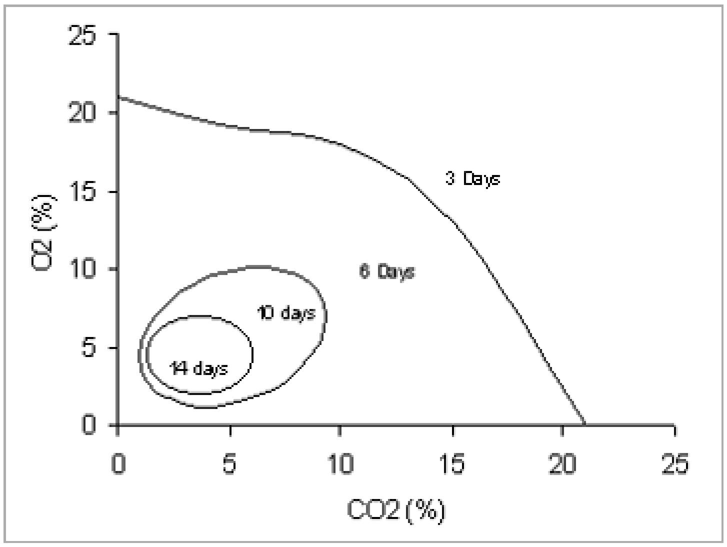

Figure 5: Effect of Atmosphere on Shelf Life

Light:

For most commodities light is not an important influence in their postharvest handling. However green vegetables, in the presence of sufficient light, could consume substantial amounts of CO_2 and produce O_2 through photosynthesis. These reactions antagonise the process of respiration and alter the pack atmosphere.

Shock and vibration:

Damage to produce cells causes an increase in respiration and may lead to enzymes being released that will cause browning reactions to begin. Damage sites can also lead to bacterial and fungal infections that would otherwise not be able to take hold.

MAP APPLICATIONS

Vegetables:

Significant increases in shelf-life can be achieved by custom designing a MAP pack with the optimum O_2 and CO_2 concentrations required by the packaged vegetables.

Because respiration and transpiration continue after harvest, once the produce is detached from its source of water, photosynthates and minerals, it is entirely dependent on its own food reserves and moisture content. Water loss is a reduction of saleable weight and thus a direct loss to the grower or processor. A loss in weight of only 5% will cause many vegetables to appear wilted or shriveled - and under warm, dry conditions without the correct packaging this can happen in only a few hours. Even in the absence of visible wilting, water loss can cause a loss of crispness and undesirable changes in colour and palatability in some vegetables.

Because MAP films are especially designed to lower the respiration rate of the packaged produce, water loss is significantly slowed and the produce remains in a fresh, saleable condition for an extended period.

Fruit:

MAP can extend the storage life, maintain the quality, and reduce the postharvest losses of most fruits by optimising the atmospheric composition inside the sealed package.

One of the major benefits of MAP is the prevention or retardation of fruit senescence (ripening) and associated biochemical and physiological changes. Fruit ripening involves a complex of mostly biochemically independent changes that transform the mature but unripe fruit into an overripe and clearly senescent fruit. Temperature is the most effective environmental factor in the prevention of fruit ripening. Both ripening and $C2H4$ production rates increase with an increase in temperature. To delay ripening, fruits should be held as close to 0°C as possible without causing any chilling injury. The use of MAP as a supplement to proper temperature maintenance to delay ripening is consequentially more effective for chilling sensitive fruits, but is generally beneficial for all fruits. Reducing $O2$ concentration below 8% and/or elevating $CO2$ concentration above 10% retards fruit ripening. It has been established that 2% $O2$ is the lower limit tolerated by most fruits.

Custom designing each MAP film to suit the specific packaged fruit, and its corresponding transportation, storage and sales requirements will ensure that optimum results are achieved.

Prepared Salads:

Consumer demand for freshness and convenience has led to the evolution and increased production of several kinds of minimally processed vegetables. For added convenience in the home or food service establishment, several produce items are often combined. Mixed prepared vegetables and salads deteriorate rapidly in quality and have short shelf lives. Prepared salads have the difficulty of having several different components all with widely varying requirements and respiration rates. Cut or shredded plant tissues also deteriorate more rapidly and have an inherently shorter shelf-life than produce marketed in a "whole" condition. Small pieces of tissue are more susceptible to moisture loss and wilting, and the cut surfaces dry out and frequently become discoloured. In addition, the juices exuding from the damaged cells at the cut surfaces provide an excellent growth medium for microorganisms, particularly mould and yeasts.

By investigating each component individually and as a complete product, MAP films can be developed to provide an optimal solution for any prepared salad mix.

- Map benefits to growers/producers include:
- More consistent product for customers
- Increased opportunities for supply to major outlets
- Increased branding and marketing opportunities
- Longer shelf life - fewer deliveries, reduced requirements for working

weekends/public holidays
- Ability to hold produce longer to take advantage of market price fluctuations - ie. hold low sell high.
- Inherently safer product with physical protection from contaminants, foreign matter and pathogens
- Extension to HACCP and QC systems, and traceabiltiy right to consumer

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