Modified atmosphere packaging: Not as simple as it seems.

By Jenny Jobling

Modified atmosphere packaging can be used to extend the shelf life of many fruit and vegetables. This technology seems straightforward as it uses permeable films and the respiration rate of the product at a specific temperature to change the concentration of carbon dioxide and oxygen around the product. However many users under estimate the complexity of this seemingly simple packaging system. This article aims to highlight the main variables involved in creating a modified atmosphere package. A better understanding of these principles will ensure users get the most out of this packaging system.

Table 1: Some examples of products that benefit from Controlled Atmosphere or Modified Atmosphere storage*.

Product	Temperature ^{o}C	Oxygen (%)	CO_2 (%)	Storage life in air (days)	Storage life in CA /MAP (days)
Apple, Gala	0 - 2	1.5 – 2.5	1 - 5	120	180
Avocado	5 - 13	2 - 5	3 - 10	42	84
Banana	13 - 16	2 - 5	2 - 5	28	49
Bean, snap	4 - 8	2 - 3	4 - 7	7	14
Broccoli	0 - 1	1 - 3	5 - 15	28	56
Lettuce	0 - 1	2 - 5	< 1%	21	28
Pear	- 1 - 1	2 - 3	0 - 1	90	180
Pepper, Bell	7 - 12	2 - 5	2 - 5	21	28
Strawberry	- 0.5 - 0	5 - 10	15 - 20	14	21

*From Transicold (1995). Controlled Atmosphere Handbook and Optimal Fresh (2000). CSIRO Publishing.

The main aim of modified atmosphere packaging (MAP) is to change the composition of the atmosphere around the product so that the storage life of the product can be extended. Most fruit and vegetables age less quickly when the level of oxygen in the atmosphere surrounding them is reduced. This is because the reduced oxygen slows down the respiration and metabolic rate of the products and therefore slows down the natural aging process.

Raising the level of carbon dioxide to levels of 2 % or more can also be beneficial. Elevated CO_2 levels can reduce the products sensitivity to ethylene, it can also slow the loss of chlorophyll which is the green colour of fruit and vegetables. High CO_2 can also

slow the growth of many of the postharvest fungi that cause rots. All these effects can help to extend the storage and shelf life of fresh produce.

However, while basically a simple system for commercial usage it is critical that considerable care is paid to several factors the most important of which is temperature control.

The Theory of MA packaging

When a given weight of produce is sealed within a plastic bag, it uses oxygen and produces carbon dioxide. As the oxygen concentration inside the package falls, below about 10% the rate of respiration (oxygen use) starts to decrease. At the same time, oxygen moves into the bag through the walls of the plastic bag and carbon dioxide moves out. Oxygen and carbon dioxide move across the film in proportion to the drop in concentration of oxygen and rise of carbon dioxide concentration inside the plastic bag.

This seems simple however the rate of oxygen consumed is dependent on the following factors;

- The weight of the product in the bag
- The temperature and
- The respiration rate of the commodity. Respiration rate may vary among cultivars, seasons and growing conditions.
- The rate of oxygen and carbon dioxide movement through the wall of the bag

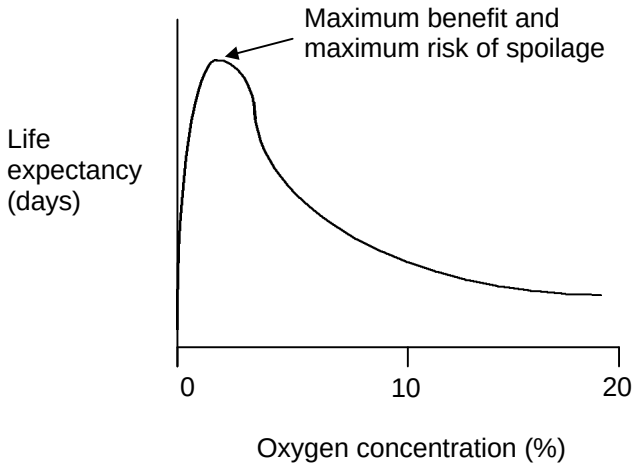
The rate of oxygen movement through the plastic bag depends on the surface area, thickness and chemical properties of the plastic film. The permeability of the film can be increased by adding holes. The commercially used film LifeSpan™ packaging is a microporous film that has a number of tiny holes and this ensures enough oxygen is supplied to the product when this film is use as recommended by the manufacturer.

The difficulty with using modified atmosphere packaging is the establishment of a stable atmosphere inside the plastic bag. MAP is a dynamic system that is not controlled. As currently used there is no feedback system that can cut in if one of the factors listed above changes. Therefore it is important to use MA packaging only as recommended by the manufacturer.

The factor that causes most problems in a commercial situation is temperature. Unfortunately the cool chain for fresh produce is not always continuous throughout the marketing system. Breaks in the cool chain such as during loading or unloading of trucks or packing of warehouses mean that the cool product can warms up. Warming of only a few degrees can be enough to cause the respiration rate of the product to rise and the oxygen within the package to fall below the recommended level. If the oxygen level falls too low then anaerobic respiration can be initiated. If this happens alcoholic off flavours develop within the product, making it unmarketable.

There is always a risk/benefit when using modified atmosphere packaging, particularly when a low oxygen atmosphere is providing the benefit. The following diagram illustrates this point. The greatest extension of shelf life occurs at the lowest possible oxygen concentration before anaerobic respiration is initiated. This point also carries the greatest risk. For example, if the respiration rate increases as a result of a small change in temperature then the oxygen level will fall below the critical level and off flavours will be produced. The same is true for atmospheres where the main benefit is high carbon dioxide. If respiration increases due to an increase in temperature then the level of CO_2 may rise above the critical level and the product will also be damaged and made unsaleable. There are two ways to minimise the risk of spoilage. Firstly you could use a package that provides slightly more oxygen, and so provides less benefit in terms of shelf life but the package would also have a reduced risk of spoilage. Secondly ensure that the cool chain is maintained. If you can't guarantee the temperature then you will be taking a very big risk with this type of packaging system. If the temperature rises by more than a few degrees then damage could be avoided by opening the bags to ensure adequate oxygen for the product. This is not often feasible but some packers recommend that the MA bags are opened once the product arrives at the wholesale market to ensure there is no risk of spoilage.

Figure 1: The Risk/Benefit associated with using Modified Atmosphere Packaging



Modified atmosphere packaging is a cheap and convenient packaging system that has the capacity to extend the shelf life of some commodities if it is used properly. If the complexity of the MA packaging is understood then it is more likely that the product will be handled with the proper care. The risks of this seemingly simple packaging system must always be considered.

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