

Advances In Modified Atmosphere Packaging (MAP) of Fresh Produce

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The rapid expansion of what is often referred to as the "fresh-cut revolution" has been made possible, in part, by improvements in MAP. Sophisticated packaging has facilitated:

- Extension of product shelf life to meet the demands of long distance distribution.
- Maintenance of product quality through reduction of respiration rate, browning reactions, fruit softening and decay.
- Added product convenience through portion control and resealable bags.
- Enhanced marketing through identification of brands and improved visibility of the product.

Early advances in MAP of fresh produce centered around matching appropriate plastic films to specific products. Because achieving a favorable equilibrium modified atmosphere inside a package depends on product respiration rate, product mass, film surface area, film thickness and film gas transmission rates, a diversity of products require a diversity of packaging films. Different bag sizes for the same product often require different packaging films. The science describing the relationships of the appropriate variables has often been lost and produce packaging seen as an art mastered by few.

Produce packaging has progressed in the past several years. Appropriate packaging materials have been developed for most of the more common fresh-cut products. There is consensus as to which films are appropriate for standard size packages of products such as garden salad, broccoli, and peeled carrots. Knowledge of how to effectively seal packages and reduce incidence of leakers has developed and printing capabilities have provided ever more attractive packages. Technical challenges still exist in produce packaging. Some of the technologies currently available to meet those challenges are described below.

Tailored Oxygen Transmission Rate (OTR). The flexible packaging industry has become increasingly

responsive to the specific gas requirements of fresh produce and are now providing films specifically designed for given produce items. Films for low, medium and high respiration rate commodities are now available from many package vendors and the process of matching OTR to product is being constantly refined. This has allowed fresh-cut processors to begin to provide a much greater diversity of products which now includes artichoke hearts, baby salad greens, sliced strawberries, stir fry mixes and many others. Very high respiration rate commodities such as broccoli, asparagus and mushrooms have always presented a challenge to packagers. New technologies are now allowing the manufacture of very high OTR (> 1000 cc/100in²-day) films for these applications.

Metallocene Technology. Technology developed independently by Dow Chemical Co. and Exxon Chemical Co. uses new single site catalysts to produce desired polymer resins. These catalysts, when applied to the manufacture of polyethylene and other polymers, can provide a much narrower distribution of polymer chain length, molecular weight and density. This results in flexible plastic films with very high OTR, low moisture vapor transmission rate, enhanced clarity, superior strength, low seal initiation temperature and very rapid bonding of the seal. These stronger films with stronger seals are finding wide application in produce packaging.

Microperforated And Microporous Films. Alternative approaches to providing high OTR's, especially in applications where there is limited package surface area for gas exchange, have included films with holes or pores. FreshHold, a microporous film technology owned by Albert Fisher, Inc. and P-Plus, microperforated technology owned by Print Pak, are finding applications in the rapidly emerging fresh-cut fruit market. Most cut fruit is packaged in rigid, gas impermeable trays with a permeable film overwrap sealed to the tray. Because the tray is impermeable to gases, there is reduced surface area for gas exchange. All the gas exchange must occur through the film overwrap. Until recently, few films had high

enough OTR's to be useful in these applications. Those films that had high OTR's often would not seal to the trays. Microporous and microperforated films allow much more rapid gas exchange than would normally be possible through plastic films.

Films with pores or small holes have some physical limitations. Carbon dioxide (CO₂) diffuses through plastic films 2-6 times faster than oxygen (O₂). Therefore, CO₂ exits a package much faster than O₂ enters. This results in equilibrium atmospheres of low O₂ and relatively low CO₂. A range of CO₂/O₂ permeability ratios among plastic films can provide a range of CO₂/O₂ concentrations inside packages. Because fruits and vegetables vary in their tolerance to elevated CO₂, this range of gas proportions is useful. Films with holes or pores admit O₂ and CO₂ at similar rates. Therefore, the ratios of gases that can result inside such packages are limited. It is impossible to achieve low O₂ (1-5%) without accumulating high CO₂ (15-20%). Thus, these films are applicable only for those products that tolerate high CO₂ without experiencing injury.

Many fruits are relatively tolerant of high CO₂. In fact strawberries, blueberries and some other fruits are benefited by high CO₂ which reduces mold growth and improves firmness. Fresh Hold, which is marketed as a high permeability label that can be attached to a bag or film overwrap, is gaining acceptance in the fruit packaging market because of its ability to admit sufficient gas through a very limited surface area. Microperforated films, such as P-Plus, may also be appropriate for these applications.

Tray/Lidstock Compatibility. The high OTR requirements for lidstocks sealed to impermeable trays has often conflicted with poor sealing properties. Advances in coextrusion technology, coupled with single site catalyst-based plastic resins, have provided better breathing, better sealing films just in time to meet the needs of the fresh-cut fruit industry.

Customizable Packaging Materials. Because each produce item has differing, often unique, packaging requirements, the ability to customize the package to the product has been the aim of produce

package development efforts. FreshHold labels can be customized to provide almost any desired OTR, as is true of microperforated films.

Some film vendors provide an array of OTR's by varying the thickness of a given film. Thinner films have higher OTR's. Very thin films do not run on modern packaging machinery and so this approach is limited.

Landec Corporation has developed side-chain polymer technology that allows the film OTR to increase rapidly as temperature increases, thereby avoiding anaerobic conditions subsequent to loss of temperature control. In addition, these polymers can provide very high OTR's, an adjustable CO₂/O₂ permeability ratio, and a range of moisture vapor transmission rates. These polymers are available as attachable patches that can go on bags or overwraps and represent the first truly customizable packaging system.

Antifog Properties. Potential buyers like to see fresh produce before they buy it. Therefore plastic packages need to be clear and the product visible. Condensation of water inside the bag can often occlude the view of the product. Antifog compounds have been developed that, when included in coextruded films, migrate to the inner surface of the film and prevent large water drops from forming. This results in a more attractive package and a better view of the product.

Package Management. There has emerged an increased appreciation that packaging can only deliver its promised benefits to fresh produce within a specific temperature range. In addition, an emphasis on shelf life extension has shifted to an emphasis on quality preservation. As the marketplace for fresh-cut products becomes more competitive, it is quality that sells, not shelf life. Such changes in perspective have helped realize the benefits that modern films packaging can provide.

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