CASE STUDY

Increase Shelf Life of Fresh Fruits and Vegetables with TPX™ Film Packaging

Summary

Product type: Functional Polyolefin Resin
Application: Food Packaging
Key benefits: High gas permeability | Lower cost | Reduces contamination from bacteria and dust | Complies with the JPN standards, FDA and EU regulations

Fruits and vegetables have historically been packed in bulk containers for shipment. The bulk packages are unpacked, and the product is displayed without packaging at the retail store. This traditional method of marketing and logistics is currently undergoing a transformation. / Items such as citrus fruits, apples, pears, sweet corn, and sweet potatoes are increasingly being offered in retail packs. Vegetables and salads are also being offered for sale in a variety of packaging formats, including plastic bags and two-piece plastic containers.

Packaging of fresh fruits and vegetables offers unique challenges due to the “live” and perishable nature of the products. Packing material and associated technologies must be carefully selected to ensure that the quality and freshness is maintained for an extended period during storage and distribution. Flexible and rigid forms of various plastics are currently in use for this purpose. The choice of a suitable packaging material requires multiple considerations such as convenient handling, ease of access, easy disposal, product visibility and resealability. The most important consideration, however, is choosing a material which can maintain the optimum atmosphere within the package.

Prior to harvest, fruits and vegetables consume carbon dioxide and give out oxygen. After harvest, they continue to actively metabolize, consuming oxygen to oxidize sugars while producing carbon dioxide, water, and heat. Fruits and vegetables also lose moisture through their skins via transpiration. Excessive loss of moisture can cause shriveling and deterioration of flavor.

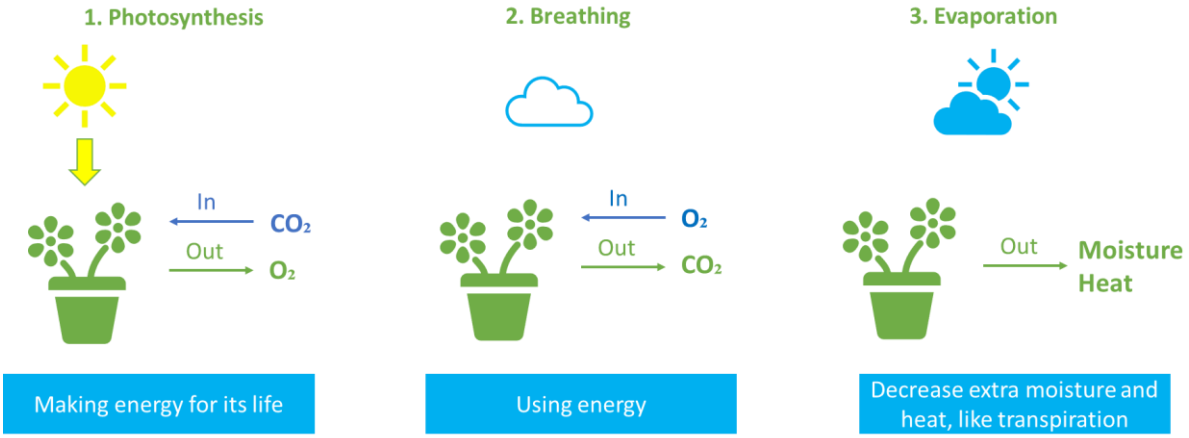

Figure 1: *The exchange of gases and moisture between a plant and the surrounding atmosphere before harvest*

Maintaining the right balance of oxygen, carbon dioxide and humidity around the products is the key to extending the shelf life. Modified atmosphere packaging (MAP) maintains an internal atmosphere in which concentration of gases and level of humidity differs from the external values. In order to maximize the shelf life of the product, the optimum atmosphere inside the package must be achieved quickly after packaging and maintained for as long as possible. The respiration rate of the produce and permeability of the packaging film determine the equilibrium levels of oxygen, carbon dioxide and humidity in the package. At equilibrium, there is a delicate balance between exchange of gases due to respiration and exchange due to permeability of the packaging film. MAP has gained huge traction in recent years as it provides the following benefits:

- Extends shelf life of products
- Enhances color, flavor, and texture
- Ensures hygiene
- Logistical
- Reduces food waste

The Challenge

The four primary variables that must be maintained within a suitable range, inside a modified atmosphere package, are relative humidity, and the concentrations of oxygen, carbon dioxide, and ethylene. The optimum values for these variables can vary depending on the commodity. After harvest, oxygen is consumed, and carbon dioxide is produced by fruits and vegetables to generate energy for the internal processes.

Without a package, fresh produce can lose moisture quickly which leads to withering, discoloration, loss of gloss, shrinkage, and deterioration in taste. In a sealed package, which acts as a gas barrier, the concentration of carbon dioxide increases, and oxygen is depleted.

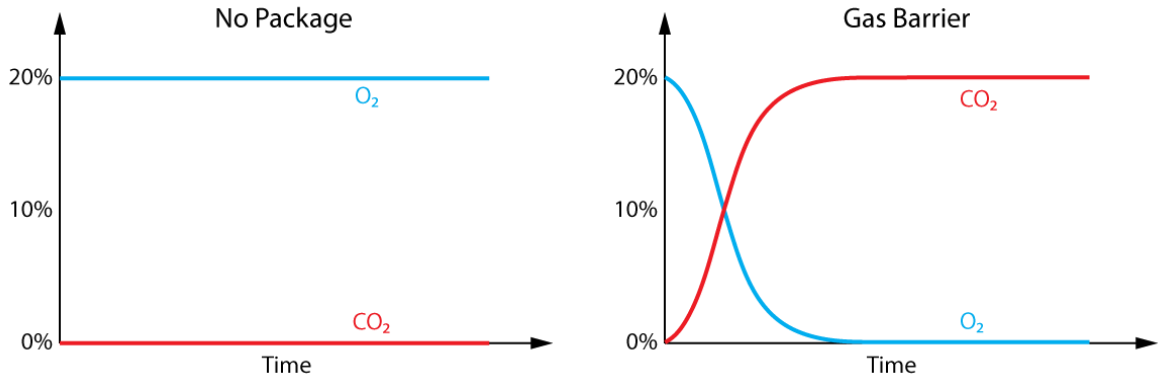

Figure 2: *Comparison of the variation in the levels of oxygen and carbon dioxide around fruits and vegetables without a package and inside an impermeable sealed package.*

The change in the gaseous composition, inside a gas barrier package, inhibits the respiration process leading to deterioration in quality. Transpiration from the product's surface also increases the humidity level inside the package to an undesirably high level. Very high humidity (> 90%) can cause the product to eventually rot.

Permeability of the plastic film allows oxygen to be replenished and excess carbon dioxide to escape from the package. The humidity level can also be kept under control if water molecules are allowed to escape through the permeable film. Low permeability leads to low concentration of oxygen, high concentration of carbon dioxide and high relative humidity inside the package.

To compensate for the low permeability, the plastic film is perforated with micro holes during the converting process. These holes, however, allow dust and bacteria into the package causing contamination. The fragrance and flavor may also be lost through the micro perforations. Micro perforations are made in the plastic film after extrusion using specialized laser equipment. The extra processing increases the cost of the film which adds to the cost of the packed product.

The Solution

TPX™ (Polymethylpentene) is a transparent, heat resistant plastic from Mitsui Chemicals. It is low density material among thermoplastics currently available for commercial use.

Property	Value
Heat Resistance	Tm : 220 ～ 240 ℃
Transparency	Haze < 5%
Gas Permeability	**10x larger than PE**
Low Density	Density : 833 kg/m3

Table 1: *Unique properties of TPX™ by Mitsui Chemicals*

TPX™ has gas permeability over 10 times higher than polyethylene (PE). It shows greater transparency than polycarbonate (PC), polypropylene (PP) and polyester. In addition, it has excellent heat-resistance, release, and chemical resistance. These properties make TPX™ an ideal material for the production of films for packaging of fruits and vegetables. Its low density produces a lighter film which reduces the load for transportation. TPX™ is a halogen-free resin denoted as an environmentally friendly material.

TPX™ has the highest permeability when compared to other commonly used packaging materials. The table below shows that a 50µm TPX™ film has more than 3 times the permeability to water as compared to PET, and more than 30 times the permeability to oxygen and carbon dioxide as compared to OPP.

	Water (H_20)	Oxygen (O_2)	Carbon dioxide (CO_2)
Condition	40℃ 90%RH	23℃ 0%RH	23℃ 0%RH
	g/m² 24hr	cm³/m² 24hr	cm³/m² 24hr
TPX™	54	30,000	100,000
OPP	3.9	831	2,910
PET	16.1	41.6	179

Table 2: *Comparison of the permeability of TPX™ with OPP and PET with respect to water, oxygen, and carbon dioxide (film : 50㎛, water : different pressure method, Oxygen carbon dioxide : equal pressure method)*

To further showcase the excellent gas permeability of TPX™ resin, a pea sprouts growing test was conducted. Two samples were created starting from the same elements, in the same conditions. The only difference between the two is that in the first sample TPX™ film was added. The two samples were monitored for 7 days and the positive impact of adding the TPX™ film is presented in Video 1 below.

Video 1: *TPX™ film impact on growth (pea sprouts growing test)*

The cost of a TPX™ film is much lower than the cost of a PP film with micro perforations. This is because TPX™ does not require additional processing for creating micro perforations due to its high permeability. TPX™ films cost about one-third less than a micro perforated PP film.

Tests comparing the sugar content, sour content, and peel condition of Japanese citrus, packed in micro perforated PP film and non-perforated TPX™ film, one month after harvest, show that the quality of the product is preserved equally well by both films. Taste tests also confirm that TPX™ performs as well as a micro perforated PP film in preserving the flavor and aroma of fruits.

Fruits Property	PE film with micro perforations	TPX™ Film
Sugar Content	15.4%	15.1%
Sour Content	0.94%	0.91%
Peel Condition	No Wither	No Wither

Table 3: *Comparison of sugar content, sour content, and peel condition between TPX™ and PP film with micro perforations*

Conclusions

TPX™ is **ideally** suited for the packaging of fresh fruits and vegetables due to its high gas and water permeability. It is especially useful for packaging of products containing high moisture content which tend to rot in packages made with ordinary plastic films. TPX™ film can be used without micro perforations due to its high permeability. The elimination of the micro perforation process reduces the cost of TPX™ as compared to perforated films. The absence of holes also prevents contamination of

the product with dust and microbes. Furthermore, micro perforations can compromise the film strength allowing a tear to propagate and rupture, exposing the product. TPX™ allows tailoring of film permeability through variation of film thickness; this flexibility can help design a package that maintains the optimal levels of oxygen, carbon dioxide and humidity for a given product. TPX™ grades comply with the JPN standards, FDA, and EU regulations. The material is suitable for making food wraps and microwave oven table ware. It is also suitable for food preservation packs and baking cartons.

Based on food type, the fresh food packaging market is classified into fruit, vegetable and salad segments. According to the Freedonia Group, the market size for produce packaging in the US exceeds $6 billion and is projected to grow at the rate of 4.0% per year. The European fresh food packaging market was valued at approximately $3.7 billion in 2017 and is expected to reach $4.9 billion by 2026. The handsome growth in the market for fresh produce packaging offers an excellent opportunity for manufacturers of packaging films. TPX™ is backed by the expertise and technical support of Mitsui Chemicals. The company can help current and new producers of packaging films in taking advantage of this opportunity to produce the packages for tomorrow.

Request a sample of TPX™ MX002O Product Today

CONTACT MITSUI CHEMICALS

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