

TECHNICAL BULLETIN: FRESH VEGETABLES PACKAGING



1 Introduction

In the period between 1990 and 1994, the value of fruit and vegetable exports on a world scale went from 58,000 to 65,000 million US\$, which equals to an annual increase of 1,300 million US\$ [1].

Fruit and vegetables register the largest increase and represents more than 85% of the total increase during such period. The line of fresh and preserved fruit represents 41%, being the best value for the total exports, followed by fresh and processed vegetables with 33%, processed fruit 17%, and processed vegetables 9% [1].

The commerce and export of non-traditional agricultural products in Latin American countries is experiencing an extraordinary dynamism compared with traditional exportable products such as cereal, coffee, tea, cocoa, sugar and spices. Lines such as fruit and edible plants (processed and fresh), flowers, forest and fishing products, nuts, seeds, timber, oilseeds and others register a substantial increase in their share in the total agricultural and livestock, increasing the relevance from 26% in 1980 to almost 50% in 1992 [1].

This situation indicates that the structure of agricultural exports tends to fit within the consumption patterns of the international markets, in which there is a dominating tendency towards nutritionally oriented products that favor health improvement, exotic products consumption and the demand of products that fit with the new consumption habits, such as the preferences for fresh, organic, frozen foods, easy to prepare at home [1].

In the case of the Andean countries exists a high potential of production and diversification of agricultural or traditional products, which require a coordinated effort and development of strategic alliances among the different participating parties in both production and commercialization networks in order to elaborate an exportable, competitive and sustainable offer [1].

An element which has contributed in a superlative form in the increase of the commerce of fresh agro-

industrial products is the development of new and improved packages (rigid and flexible).

The new food product packages are responsible for contributing with the following benefits to the commercialization chain:

- Health: The package should guarantee that consumers acquire fresh products, free from pathogenic organisms, of high nutritional value and with the lowest conservative and preservative levels.
- Waste reduction: According to data from the World Health Organization it is estimated that between 35 and 50% of the food products are wasted in the commercialization line. The contribution of the plastic package in reducing this diminishing factor is highly important.
- Comfort: In general terms, the sensibility of opening a package and avoid the taking different ingredients, washing, cutting and mixing them has been well received [2,3].

The fresh vegetable packaging is a high technology process and extremely specialized, as a consequence of the desired control of air capacity of the product, water absorption, byproduct formation, etc. [4].



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2 Modified atmosphere package (MAP)

The development of packaging technology introduced in Europe in 1970 the concept of "modified atmosphere packages (MAP)" [4].

A modified atmosphere is the one resulting from the alteration from the normal gas mixtures comprising the air (78% nitrogen, 21% oxygen, 0.03% carbon dioxide and traces of noble gases). The modification of the normal mixtures of gases in the air seeks to increase the useful life and vegetable quality to be packaged, by feeding the aging and decomposition metabolism of same [4].

The MAPs are in charge of changing the product metabolism establishing an adequate balance among the atmospheric gases and those generated by means of breathing of the vegetable [5]. In order to understand the MAP mechanism, it is necessary to understand what happens to the vegetables when go through various storage conditions.

2.1 Case 1: Without package (Aerobic conditions).

A vegetable in aerobic conditions is capable of absorbing oxygen (O_2) and liberating carbon dioxide (CO_2) as it is illustrated in Figure 1. In this form, the vegetable transforms stored sugars into energy (process known as Krebs cycle). Under these conditions, the vegetable tends to ripen quickly, lose vitamins, turn brown and have a short useful life, which is unfavorable from the commercial point of view [5].

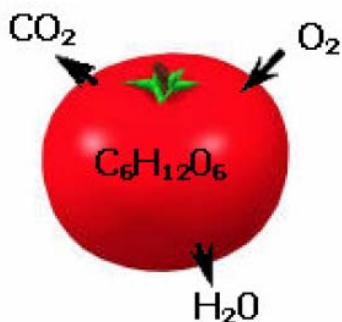


Figure 1. Aerobic breathing.

2.2 Case 2: Vacuum packaging (Anaerobic conditions):

When a vegetable is vacuum packaged (with less than 2% O_2), it transforms the stored sugars into energy by means of a glycolic form (Figure 2), since there is not enough O_2 to do this by the Krebs cycle. This fermentation reaction generates products such as alcohols, aldehydes and organic acids, which are responsible for undesirable product odors and flavors, and that cause as a consequence lower freshness, in spite of the vegetable does not turn brown [5].

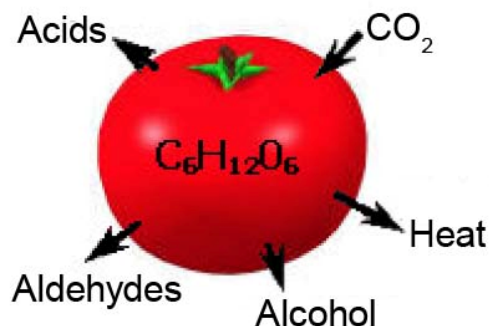


Figure 2. Anaerobic breathing.

2.3 Case 3: Modified Atmosphere Package (MAP).

MAP is responsible for modifying the relative O_2 and CO_2 levels which surround the vegetable, as well as eliminating other gases such as ethylene, and expelling the humidity generated by breathing, such as it is shown in Figure 3.

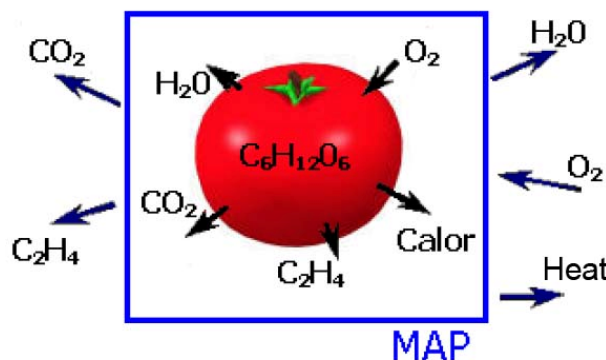


Figure 3. MAP breathing.

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In order to alter the metabolism of the packaged product and thus extending its life and freshness, the oxygen level has to be reduced and the carbon dioxide level elevated. Based on these principles, the controlled atmosphere package should:

1. Control the oxygen entry into the package, in order to reduce the oxidation grade of the sugars used by the plant to generate energy [5,6].
2. Promote the exit of the carbon dioxide from the inside of the package (CO_2) released in the breathing process of the vegetable in order to avoid the fermentation exhibited at low oxygen concentration (O_2) [5,6].
3. Allow the escape of enough humidity in order to minimize the condensation (beyond the correctible by the addition of anti-fog additives) without dehydrating the product.
4. Ethylene permeation (C_2H_4) released by the fruit as part of its metabolic activity. This simple, organic component triggers, in some products, its ripening and ageing; this explains why some fruit such as the banana and avocado ripen faster when stored in containers, along with damaged fruit or too ripe; or that the broccoli turns yellow even when stored in the refrigerator.



Each food product has its own gas composition and optimal humidity level. The modified atmosphere package allows to reach this balance point, making it superior when compared to the traditional package in waterproof bags, wherein is difficult to reach the gas balance and especially the handling of water steam [8].

3 Environmental requirements of vegetables.

MAPs should be specifically designed to endure handling conditions, ethylene sensitivity and vegetable breathing rate to be packaged, since each type of product has physical and biological features that require different film structures, in order to create an optimal controlled atmosphere (Chart 1). There is not just one unique effective film or atmosphere for all products, therefore the breathing processes of the vegetable to be packaged must be carefully studied, as well as the permeation properties of the film to be used.

Chart 1. Controlled atmosphere requirements for different vegetables [9].

Vegetable	% O_2	% CO_2
Cauliflower	2 – 4	2
Tomatoes	3 – 5	0
Cabbage	1 – 2	5 – 10
Lettuce	1 – 3	1

Additionally, it is important to point out that the breathing rates considerably vary with the temperature, and for most vegetables, they can multiply up to 6 with a change from 0°C to 15°C (see Chart 2), whilst the permeation of the films will double [10]. That is why additional storage requirements at low temperatures is required.

Most of the packaged vegetables have optimal storage temperature conditions between 0 and 2°C and 85 to 95% of Relative Humidity.

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Chart 2. Average breathing and ethylene production rates of vegetables usually found in packaged salads.

Vegetable	Temperature (°C)						C ₂ H ₄ Prod ($\mu\text{L C}_2\text{H}_4 \text{ kg}^{-1} \text{ h}^{-1}$)
	0 °C	5 °C	10 °C	15 °C	20 °C	25 °C	
Lettuce (Head)	12	17	31	39	56	82	Very Low
Lettuce (Leaves)	23	30	39	63	101	147	Very Low
Broccoli	21	34	81	170	300	Na	< 0.1 (20 °C)
Cabbage	5	11	18	28	42	62	< 0.1 (20 °C)
Carrot	15	20	31	40	25	Na	< 1.0 (20 °C)
Cauliflower	17	21	34	46	79	92	< 1.0 (20 °C)
Cucumber	Na	Na	26	29	31	37	0.6 (20 °C)
Endive	45	52	73	100	133	200	Very Low
Radicchio	8	13 ⁽ⁱ⁾	23 ⁽ⁱⁱ⁾	Na	Na	45	0.3 (6 °C)
Tomatoes	Na	Na	15	22	35	43	10.0 (20°C)

(ⁱ) Measured at 6 °C (ⁱⁱ) Measured at 7.5 °C Na: Not Available

Packages which are usually made of polyethylene films (PE) are used to wrap fruit and vegetables, which permeation is featured in Chart 3. The main benefits from using PE in MAPs are [10]:

- High transparency and brightness.
- High resistance to tearing and penetration.
- High oxygen barrier.
- High water steam barrier.
- Easily printable.
- High sealing speed.
- Low cost.

Chart 3. Gas transmission rates in films of 25 μm (23°C).

PE	O ₂ TR(i) cc / m ² / 24h	WVTR (II) cc / m ² / 24h	CO ₂ TR (iii) cc / m ² / 24h
PEAD	70	0.20	120
PEMD	120	0.30	Na
PEBD	200	1.40	770
PELBD	200	0.40	Na

(i) Oxygen Transmission rate

(ii) Water Steam Transmission rate

(iii) Carbon Dioxide Transmission Rate

Chart 4 summarizes the effect of using MAP packages in certain vegetables and the typical material used for each case.

Chart 4. MAP effects for different vegetables [11].

Vegetables	Lettuce	Mushrooms	Peeled Potatoes
Gas Mixture	3-10% CO ₂ + 3-10% O ₂ + 80-94% N ₂	3-10% CO ₂ + 3-10% O ₂ + 80-94% N ₂	3-10% CO ₂ + 40-60% N ₂
Typical Shelf Life	2 – 5 days	2 – 3 days	0.5 hrs 2 days (sealed)
MAP Shelf Life	5 – 10 days	5 – 6 days	10 days
MAP Typical Material	PEBD / OPP	PEBD / OPP	OPET / PVdC / PE-PVC / PE-PA / PE
Storage Temperature	+3 to +5 °C	+3 to +5 °C	+3 to +5 °C

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4 MAP benefits

The use of MAP in applications of fresh vegetable packages offers benefits both for the producer as well as for the consumer, which are:

- Better quality products for the client.
- Greater opportunities for the suppliers to sell these products to wholesale stores.
- Greater marketing opportunities.
- Longer shelf life.
- Ability to maintain the freshness of the product for a longer period of time, thus allowing the suppliers to take advantage of the offer and demand fluctuations in the market.
- Greater product protection towards pollutants, pathogens, etc.
- Provide greater product traceability for the consumer [5].



- **Venelene® 11U4 PELBD.** Attributes: High resistance to tearing, to penetration and excellent brightness.
- **Venelene® 11Q4 PELBD.** Attributes: High resistance to tearing, to penetration and excellent brightness.
- **Venelene® 11O4 PELBD.** Attributes: High resistance to tearing, to penetration and excellent brightness and sealing properties.
- **Venelene® 3200B PEAD.** Attributes: High water steam barrier.

The combination of Venelene® products can be efficiently integrated in the manufacture of MAP packages by lamination or extrusion processes.



The MAP packages represent a novel application of multi-layer Polyethylene films. Polinter avails to its clients the technical assistance and research resources in order to provide support in the development of these products for the different market segments.

5 Venelene® products for MAP packages

Polinter puts at your request a wide array of polyethylene that can be used in the manufacture of controlled atmosphere packages. The main attributes of each grade are:

- **Venelene® FA-0240 PEBD.** Attributes: Excellent processability and transparency.
- **Venelene® FD-0348 PEBD.** Attributes: Excellent processability and transparency.

6 References:

1. Competitive production and markets for fruit and edible plants in the Andean Region. <http://www.iica.org.ec/pub/frutyhort.html>
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3. Modified Atmosphere Packaging; Nazir Mir and Randolph M., Beaudry; Michigan State University; East Lansing, Michigan.
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5. Modified Atmosphere Packaging for Fresh Produce: http://www.convex.co.nz/prod_refresh_technical.html
6. Flexible Food Packaging, Questions and Answers; Arthur Hirsch; Van Norstrand Reinhold, 1991, ISBN 0-442-00609-8.
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8. <http://www.angelfire.com/ia2/ingenieriaagricola/empques.htm>
9. Vegetales Kelly's Web page: http://www.vegetales-kellys.com/productos_cm.htm
10. Finca Dos Aguas Web site: <http://www.fortunecity.com/meltingpot/oregon/1107/>
11. Fruits and Vegetables $\frac{3}{4}$ MAPAX;
12. http://www.aga.com/web2000/com/wppcom.insf/pages/fdb_fruitmapax

This bulletin has been made by the Marketing Department of Polinter with the support of the specialists of Investigación y Desarrollo, C.A. (INDESCA) and by the Technical Services Department of CORAMER. This is intended for all clients and users of the Venelene® resins and we trust that the information contained herein is helpful and useful.

Please contact us at the following email address, info@polinter.com.ve or through our agent: Corporacion Americana de Resinas (CORAMER), with branch offices in Venezuela, Colombia, Peru, Ecuador and Chile (<http://www.coramer.com>), should you have any suggestions or comments regarding this issue.

The information described in this document is, to our best knowledge, accurate and truthful. However, since the particular uses and transformation conditions are completely out of our hands, the adjustment of the parameters in order to reach the maximum performance of our products for a specific application depends on and is the responsibility of the user.

In order to obtain more detailed information of the security aspects regarding the use and disposal of our products we invite you to consult the security pages (MSDS) of the Venelene® polyethylene.