Technical Bulletin: Packaging for fresh vegetables

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1 Introduction.

In the period 1990-94, the value of world fruit and vegetable exports rose from US$58 billion to US$65 billion, equivalent to an annual increase of US$1.3 billion. [1]

Vegetables and fruits register the greatest increase and explain more than 85% of the total increase during the indicated period. The category fresh and preserved fruits represent 41%, being the highest value of total exports, followed by fresh and processed vegetables with 33%, processed fruits 17% and processed vegetables 9%. [1]

The trade and export of non-traditional agricultural products in Latin American countries has been experiencing extraordinary dynamism compared to traditional export products, such as cereals, coffee, tea, cocoa, sugar and spices. Items such as fruits and vegetables (processed and fresh), flowers, forest products, fishery, nuts, seeds, wood, oily fruits and others register a substantial increase in their participation in total agricultural exports, passing their importance from 26% in 1980 to almost 50% in 1992. [1]

This situation would be indicating that the structure of agricultural contributions tends to be coupled with the consumption patterns of international markets, in which the tendency to a diet oriented to products that favor the improvement of health predominates, to the consumption of exotic products and the demand for products in line with new consumption habits, such as the preference for fresh, organic and frozen foods that are easy to prepare at home. [1]

The Andean countries have a high potential for production and diversification of agricultural or traditional items, which requires a concerted effort and the development of strategies alliances between the various actors that participate in the production and marketing circuits to develop a competitive exportable offer and sustainable. [1]

An element that has contributed superlatively to the increase in the trade of fresh agro-industrial products is the development of new and better packaging (rigid and flexible).

The new packaging for food products is responsible for providing the marketing chain with the following benefits:

- **Health:** The packaging must guarantee that consumers acquire fresh products, free of pathogenic organisms, with a high nutritional value and with the lowest levels of preservatives and preservatives.
- **Waste reduction:** According to data from the World Health Organization, it is estimated that between 35% and 50% of food products are lost in the marketing channel. The contribution of plastic packaging in reducing this waste factor is extremely important.
- **Convenience:** in general terms, the practicality of opening a package and avoiding taking different ingredients, washing them, cutting them, and mixing them is well received [2,3]

The packaging of fresh vegetables is a highly specialized and highly technological process, as a consequence of the desired control of the product's respiration phenomena, water absorption, formation of by-products, etc. [4]

2 Modified Atmosphere Packaging (MAP)

The development of packaging technology introduced in Europe in 1970 the concept of "Modified Atmosphere Packaging" (MAP) [5].

A modified atmosphere is one that results from the alteration of the normal mixture of gases that make up the air (78% nitrogen, 21% oxygen, 0.03% carbon dioxide and traces of noble gases). The modification of the normal mixture of gases in the air seeks to increase the useful life and quality of the vegetable to be packed, by altering its aging and decomposition metabolism. [4]

The MAPs are in charge of modifying the metabolism of the product, establishing an adequate balance between the gases of the environment and those generated by the effect of the respiration of the plant. [5]

To understand the mechanism of action of a MAP, it is necessary to understand what happens to the vegetable when it goes through various storage conditions:

2.1 CASE 1: No packing (aerobic conditions)

A plant in aerobic conditions is able to absorb oxygen (O2) and release carbon dioxide (CO2) as illustrated in Figure 1. In this way, the plant converts stored sugars into energy (Process known as the Krebs cycle) . Under these conditions, the vegetable tends to ripen quickly, lose vitamins, turn brown and have a short shelf life, which is unfavorable from a commercial point of view. [5]

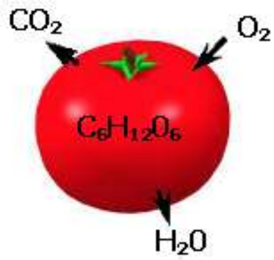

Figure 1. Aerobic Respiration.

2.2 CASE 2: Vacuum packed (anaerobic conditions)

When a vegetable is vacuum packed (with less than 2% O2) it converts stored sugars into energy via a glycolic pathway (Figure 2) since there is not enough O2 to do so via the Krebs cycle. This fermentative reaction generates products such as alcohols, aldehydes, and organic acids, which are responsible for undesirable odors and flavors in the product, and which result in less freshness, despite the fact that the vegetable does not usually turn brown. [5]

Figure 2. Anaerobic Respiration.

2.3 CASE 3: Packed in modified Atmosphere (MAP).

The MAP is in charge of modifying the relative levels of O2 and CO2 that surround the plant, as well as eliminating other gases such as ethylene, and expelling the humidity generated by respiration, as shown in figure 3.

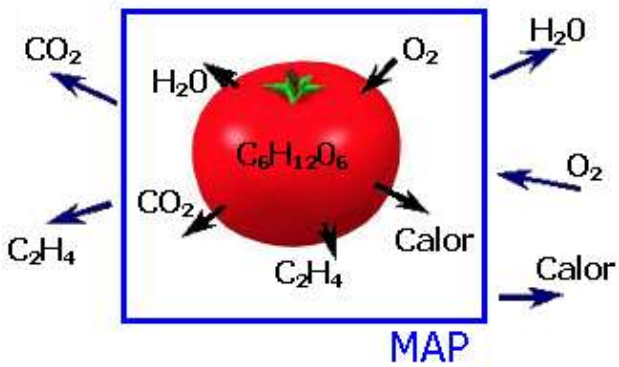

Figure 3 MAP breathing.

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In order to alter the metabolism of the packaged product and thus extend its life and freshness, it is necessary to reduce the oxygen level and raise the carbon dioxide level. Based on these principles, controlled atmosphere packaging should achieve:

1. Control the entry of oxygen into the interior of the packaging, in order to reduce the degree of oxidation of the sugars that the plant uses to generate energy. [5,6]

2. Promote the release of the carbon dioxide (CO2) released in the respiration process of the plant from the interior of the packaging in order to avoid fermentation that occurs at low concentrations of oxygen (O2). [5,6]

3. Allow enough moisture to escape to minimize condensate formation (beyond what can be remedied by adding antifog additives), without causing product dehydration. [7]

4. Permeation of ethylene (C2H4) released by the fruit as part of its metabolic activity. This simple organic component triggers, in some products, their maturity and aging; this explains why certain fruits such as bananas and avocados ripen rapidly when stored in containers, along with damaged or overripe fruits; or broccoli turning yellow even when stored in the efrigerator.

Each food product has its own gas composition and optimum moisture level. Modified atmosphere packaging allows this balance point to be reached, which makes it superior when compared to traditional packaging in impermeable bags, where it is complex to achieve gas balance and especially the handling of water vapor. [8]

3 Environmental Requirements of Plants

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MAPs must be specifically designed to withstand the handling conditions, sensitivity to ethylene, and respiration rate of the vegetable to be packaged, as each type of product has physical and biological characteristics that require different film structures to create the optimal controlled atmosphere. (Table 1). There is no single film or atmosphere that is effective for all products, which is why the respiration process of the vegetable to be packaged must be carefully studied, as well as the permeability properties of the film to be used.

Table 1. Controlled atmosphere requirements for various 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 note that respiration rates vary considerably with temperature, and for most vegetables, can be multiplied by up to 6 with a change from 0 °C to 15 °C (see table 2), while the permeability of movies will be doubled. [10]

For this reason, additional low-temperature storage requirements must be established. Optimum storage conditions for most packaged vegetables are temperatures between 0 and 2 °C and 85 to 95% relative humidity.

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Table 2. Mean respiratory and ethylene production rates of vegetables commonly present in packaged salads. [8]

Vegetable	O° C	5° C	10° C	15° C	20° C	25° C	C_2H_4 Prod.
			(mg CO_2 kg^{-1} H^{-1})				(pL C_2H_4 kg^{-1} H^{-1})
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	< 0.1 (20° C)
Cauliflower	17	21	34	46	79	92	< 0.1 (20° C)
Cucumber	na	na	26	29	31	37	0.6 (20° C)
Endive	45	52	73	100	133	200	very low
Radiccio	8	13[i]	23[ii]	na	na	45	0.3 (6° C)
Tomatoes	na	na	15	22	35	43	10 (20° C)
	i	measured at 6°C			**na**	not available	
	ii	measured at 7.5°C					

To wrap fruits and vegetables, packages made up of polyethylene (PE) films are predominantly used, whose permeability is presented in table 3. The main benefits of using PE in MAP are: [8]

- High transparency and gloss.
- High resistance to tearing and penetration.
- High barrier to oxygen.
- High water vapor barrier.
- Ease of printing.
- High sealing speed.
- Low cost.

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

PE	O_2TR (i)	WVTR (ii)	CO_2TR (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 trasmission rate		
ii	Water vapor transmission rate		
iii	Carbon dioxide transmission rate		

The Table 4 summarizes the effect of using MAP packaging on certain vegetables and the typical materials used for each case.

Table 4. Effects of MAP for various vegetables. [11]

Vegetable	Lettuce	Fungus	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	40-46% CO^2 + 40-60% N_2
Shelf life	2-5 days	2-3 days	0.5 hours
(typical)			2 days under vaccum
Shelf life (MAP)	5-10 days	5-6 days	10 days
Typical MAP material	PEBD/OPP	PEBD/OPP	OPET / PVdC / PE-PVC / PE-PA /PE
Storage Temperature	+3 a +5 °C	+3 a +5 °C	+3 a +5 °C

4 Benefits of MAPs

The use of MAP in packaging applications for fresh vegetables offers benefits for both the producer and the consumer, among which are:

- Better quality products for the customer.
- Greater opportunities for suppliers to sell their products to wholesale stores.
- Greater marketing opportunities.
- Longer shelf life.
- Ability to keep the product fresh longer, which allows the supplier to take advantage of fluctuations in market supply and demand.
- Greater product protection against contaminants, pathogens, etc.
- Provide good traceability of the product to the consumer. [5]

5 VENELENE® products for MAP packaging

Polinter puts at your disposal a wide variety of polyethylenes that can be used in the manufacture of controlled atmosphere packaging. The main attributes of each grade are:

- LDPE Venelene® FA-0240. Attributes: Excellent processability and transparency.
- LDPE Venelene® FD-0348. Attributes: Excellent processability and transparency.
- ELBD Venelene® 11PG4. Attributes: High tear strength, penetration, high hot stamp strength and excellent gloss.

The combination of attributes of Venelene® products can be efficiently integrated in the manufacture of MAP packaging through lamination or coextrusion processes.

MAP packaging represents a novel application of multilayer polyethylene films. Polinter makes technical assistance and research and development resources available to its clients, in order to support them in the development of these products for the different market segments.

6 Bibliographic references

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To obtain more detailed information on the safety aspects related to the handling and disposal of our products, we invite you to consult the safety data sheets (MSDS) of Polyethylenes Venelene®.