Making our world more productive

MAPAX® – Best for fruit and vegetables.

Linde's MAPAX® portfolio meets today's food preservation challenges with bespoke gases and mixtures, application expertise and complementary installation, test and safety services.

The permeability of packaging material is vital

A modified atmosphere must be combined with the right packaging material to achieve optimum preservation of fresh fruit and vegetables. If the products are sealed in an insufficiently permeable film, undesirable anaerobic conditions (<1% O_2 and > 2% CO_2) will develop with subsequent deterioration in quality. Conversely, if fruit and vegetables are sealed in a film of excessive permeability, the modified atmosphere will leak out and moisture loss will also lead to accelerated deterioration in quality. Examples of materials that can be used for MAP of fresh produce (fruit and vegetables) are microporous film or LDPE/OPP.

Optimal equilibrium

The key to successful modified atmosphere packaging (MAP) for fresh produce lies in a packaging film of correct intermediary permeability. This enables a desirable equilibrium modified atmosphere (EMA) to be established, where the rate of oxygen and carbon dioxide transmission through the pack equals the produce respiration rate. Typically, optimum EMAs of 3–10% O_2 and 3–10% CO_2 can dramatically increase the shelf-life of fruit and vegetables.

The EMA thus attained is influenced by numerous factors such as the respiration rate, temperature, packaging film, pack volume, fill weight and light. The respiration rate, in turn, is affected by the variety, size and maturity of the produce as well as the extent to which it has been processed. Consequently, determining the optimum EMA of a particular item is a complex challenge that can only be solved through practical experimental tests.

Recommended gas mixtures for fruit and vegetables

Product	Gas mixture	Gas volume / Product volume	Typical shelf-life Air	Typical shelf-life MAP	Storage temp.
Lettuce	5% O_2 + 5–20% CO_2 + 75–90% N_2	100–200 ml / 100 g prod.	2–5 days	5–8 days	3–5°C
Fresh cut salad mix	5% O_2 + 5–20% CO_2 + 75–90% N_2	100–200 ml / 100 g prod.	2–5 days	5–8 days	3–5°C
Fresh cut carrots	2–5% O_2 + 15–20% Co_2 + 75–83% N_2	100–200 ml / 100 g prod.	2–5 days	5–8 days	3–5°C
Fresh herbs	0–5% O_2 + 5–20% CO_2 + 75–95% N_2	100–200 ml / 100 g prod.	1–3 days	10–18 days	3–5°C
Fruit salad mix	0–5% O_2 + 5–20% CO_2 + 75–95% N_2	100–200 ml / 100 g prod.	1 day	3–6 days	3–5°C
Sliced apple	0–5% O_2 + 5–20% CO_2 + 75–95% N_2	100–200 ml / 100 g prod.	1–2 days	8–12 days	3–5°C
Pineapple peeled, cut	5–10%O_2 + 10–15% CO_2 + 75–90% N_2	100–200 ml / 100 g prod.	2–5 days	6–9 days	3–5°C
Pre-peeled potatoes	40–60% CO_2 + 40–60% N_2	100–200 ml / 100 g prod.	0.5 hours	10 days	3–5°C

Finding the right gas/packaging combination

The optimum MAP can be achieved by either sealing the produce in air or gas flushing with 3–10% O_2 and 3–10% CO_2 and 80–90% N_2. As previously explained, modified atmospheres evolve within an air-sealed pack because of produce respiration. However, there may be circumstances when it is desirable to gas flush so that a beneficial EMA is established more quickly. For example, the enzymatic browning of salad vegetables can be delayed by gas flushing compared with air packing. We offer practical tests to demonstrate this for our customers' specific produce. Different conditions may apply for peeled potatoes and apples, which should not be packed with oxygen because of enzymatic reactions that bring about brown discolouration. Pre-peeled potatoes, for example, can be packed in 40–60% CO_2 + 40–60% N_2, prolonging their shelf-life from 0.5 hours to 10 days at 4 to 5°C.

Classification of selected fruit and vegetables according to their respiration rate and degree of perishability in air and 3% O_2

Commodity[b]	Respiration rate – CO_2 production (ml kg^{-1} h^{-1})[a] In air 0°C	10°C	20°C	In 3% O_2 0°C	10°C	20°C	Relative respiration rate at 10°C in air
Onion (Bedfordshire Champion)	2	4	5	1	2	2	Low <10
Cabbage (Decema)	2	4	11	1	3	6	
Beetroot (storing)	2	6	11	3	4	6	
Celery (white)	4	6	19	3	5	12	
Cucumber	3	7	8	3	4	6	
Tomato (Eurocross BB)	3	8	17	2	3	7	
Lettuce (Kordaat)	5	9	21	4	6	14	
Peppers (green)	4	11	20	5	7	9	Medium 10–20
Carrots (whole, peeled)	—	12	26	—	—	—	
Parsnip (Hollow Crown)	4	14	23	3	6	17	
Potatoes (whole, peeled)	—	14	33	—	—	—	
Mango	—	15	61	—	—	—	
Cabbage (Primo)	6	16	23	4	8	17	
Lettuce (Kloek)	8	17	42	8	13	25	
Cauliflower (April Glory)	10	24	71	7	24	34	High 20–40
Brussels sprouts	9	27	51	7	19	40	
Strawberries (Cambridge Favourite)	8	28	72	6	24	49	
Blackberries (Bedford Giant)	11	33	88	8	27	71	
Asparagus	14	34	72	13	24	42	
Spinach (Prickly True)	25	43	85	26	46	77	Very high 40–60
Watercress	9	43	117	5	38	95	
Broad beans	18	46	82	20	29	45	
Sweet corn	16	48	119	14	32	68	
Raspberries (Malling Jewel)	12	49	113	11	30	73	
Carrots (julienne-cut)	—	65	145	—	—	—	Extremely high >60
Mushrooms (sliced)	—	67	191	—	—	—	
Peas in pod (Kelvedon Wonder)	20	69	144	15	45	90	
Broccoli (sprouting)	39	91	240	33	61	121	

[a]mg CO_2 converted to ml CO_2 using densities of CO_2 at 0°C = 1.98, 10°C = 1.87, 20°C = 1.77.

[b]Unless stated, produce is whole and unprepared.

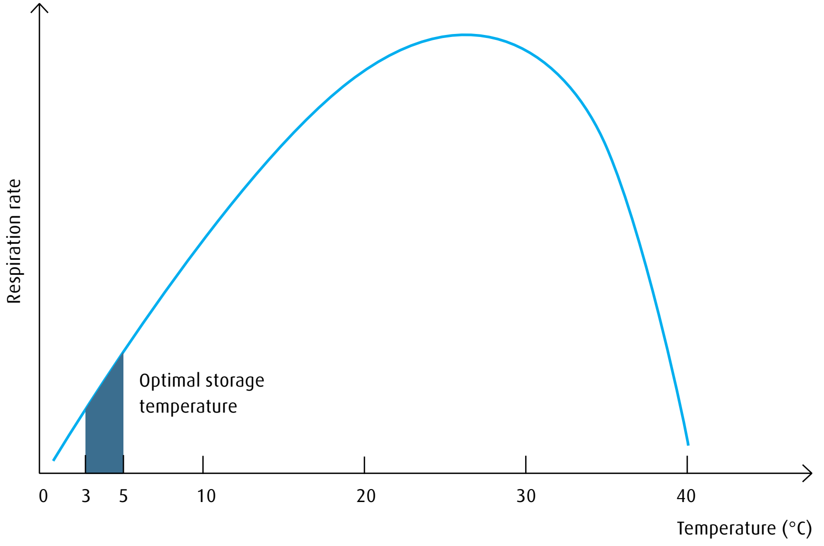
Respiration of fruit and vegetables

All living plants respire, i.e. different organic compounds, mainly sugar compounds, provide energy to other life processes in the cells. This conversion of sugar to energy needs oxygen. Air contains 21% oxygen. When sufficient oxygen is available, the respiration is aerobic. If the concentration of oxygen drops, respiration becomes anaerobic. Anaerobic oxidation leads to intermediate products with undesirable odours. Respiration is a complicated process which involves a series of enzymatic reactions. The entire aerobic process can be described in simplified form as:

sugar + oxygen (O_2) →
carbon dioxide (CO_2) + energy + water

The respiration rate is measured as generated ml CO_2/kg x hour or as used ml O_2/kg x hour.

Respiration rate depends on the temperature



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