

IV Range Packaging freshness

In the sector of fresh produce or 4th range products, today new packaging technologies contribute to maintain product quality and properties unchanged, from the preparation until consumption

Consumptions of fourth range products (ready-to-eat fresh-cut vegetables) registered a constant growth in recent years: between the year 2004 and 2005, sales have increased by 22%, and in the first six months of 2006 they have grown of an additional 15%. This corresponds to a purchase by Italian families of approx. 58 kg of ready-to-eat fresh vegetables, 10% of total fresh vegetables sales, amounting to about

half a billion Euro. This market boom mainly results from the properties of this product, perfectly in tune with the lifestyle of modern consumers, more and more hasty, attentive to ease-of-use and costs, but also demanding as for the quality and safety of what they are going to eat. Next to their quick and practical use, fourth range produce can profit of another asset: they guard their freshness and appetising appeal when stored in a cool environment, for a period of 4-10 days, thanks to careful cleaning and packaging, specifically in order to maintain the organoleptic, microbiological and sensorial properties along the entire product's shelf-life.

The production process

The production process for fourth range vegetables integrates: selection and cleaning, washing, cutting, rinsing, drying, and, finally, portioning and packaging. A process consisting of a few simple and delicate steps, due to the perishability of these products. Vegetables, in fact, are living organisms, which breath and transpire even after picking, with consequences that highly affect their life. Their high water content makes them highly vulnerable to bacteria and fungus; they are subject to a spontaneous, endogenous and degenerative process called senescence, that cannot be stopped but only slowed down. Senescence is characterised by a series of catabolic and degrading reactions, which cause bio-chemical mutations, some of which are desired (creation of colour and scents), others detrimental (loss of weight, freshness, and nutritional value). Finally, in fourth range produce, senescence and its





negative effects are accelerated by the cutting and handling to which they are subject, which are stressing for the vegetable product. This results in a modification of the cell metabolism, whose effect varies according to the cut and to the product. In order to limit these reactions and slow-down senescence, it is necessary to: select top quality raw materials (little contamination, at the right stage of ripeness, well preserved), act on some parameters, especially during the storage and packaging which are the most difficult steps along the chain), and select the most adequate packaging systems and materials.

Parameter control

For the constant quality and safety of fresh produce, several parameters need accurate control, and temperature certainly is the most important one: the cold chain should never be interrupted, to make sure that all production steps occur at the lowest possible temperature, i.e. suitable to minimise spoilage reactions without causing physiological disorders. The relative humidity is another important control parameter, since the loss of water, unavoidable

consequence of transpiration, is one of the main causes of physiological deterioration in vegetables (loss in weight, crispiness, softening). To reduce it, low temperature and high relative humidity are required, although these conditions bear the risk of creating condensate inside the package thus favouring microbial growth. Even atmosphere composition highly affects preservation: the atmosphere inside the package is different from the real atmospheric composition, as O_2 decreases while CO_2 increases. Each fresh produce has limiting gas values that must be complied with, in order to avoid harmful consequences, and optimal values, at which it is best preserved for a long time. Another important element concerns the emission of ethylene, a phytohormone that highly influences the ripening of fruit and vegetables. The concentration of ethylene has to be carefully controlled, since this substance produces enzymatic degradation in tissues and, in some vegetables like tomatoes, autocatalytic ethylene production is possible. Hence, the

presence of hexogen ethylene causes a higher production of endogenous ethylene that

further enhances the ripening processes.

Eventually, the minimisation of mechanical damages is important. Bruises or lacerations of external membranes cause considerable water losses. The consequence of these impacts can be: higher breathing activity; accumulation of toxic metabolics; acceleration of undesired biochemical reactions; higher production of ethylene. And all these reactions favour the penetration of microorganism.

Packaging: novelties in the market

Next to the parameter control as described before, for the best preservation of fresh produce (fourth range produce), a suitable packaging system is required that, next to the conventional functions of protection, presentation and labelling space, can also:

1. *facilitate or limit, according to circumstances, the changes related to the breathing and physiological metabolism of the produce* (colour, chemical composition, structure, etc.), to make sure that the regular breathing activity of the food product is not prevented, thus preserving it from reactions that may jeopardise its quality. Hence, the gas permeability of the packaging material is of primary importance. In fact, an inadequate material brings about various risks, as it can produce anaerobic conditions that prevent the product's breathing, thus triggering fermentation processes



that lead to the production of unpleasant odours and tastes. On the contrary, high permeability produces oxidation reactions that cause a rapid degradation of the product's quality. Another basic issue is the permeability to water vapour: if it is too low, it may cause condensate inside the package; if too high, it may dry out the product, causing weight losses. To get round these inconveniences, pierced materials could be used the piercing can be performed using piercing machines equipped with hot needles, laser heads or electric discharges. These materials allow an adequate exchange of gas, and provide the necessary ventilation in order to reduce water losses and, hence, weight losses. The piercing (diameter of the holes, their density, etc.) is selected according to the breathing rhythm and water content of the food product, as well as in accordance to the film permeability. A recent alternative to pierced materials came with bi-oriented polypropylenes (BOPP), produced with latest *multilayer extrusion technologies* combined with the use of new *master batches*. These films, produced in various layers using specific *tie-layers*, provide high oxygen and low water vapour permeability, while eliminating the risks of microbial contamination, as they are free of holes. In this case, the disadvantage is the low oxygen permeability range, which can be obtained compared to micro-pierced material. Another innovation comes with the films that can change their permeability with temperature, produced with special polymeric chains acting as gas barrier when in crystal state, but that, above the *switch*



temperature, dramatically change their behaviour switching to the amorphous state and becoming more permeable. This result is obtained with films consisting in two layers of different materials (or two layers of the same material), with micro-slits: in case of temperature changes, the various layers expand at different speeds, thus notably increasing the film permeability. Studies on the use of a vegetable parchment are on the run; it is a genuine vegetable cellulose-based material, with natural micro-pores, that protects the product from water and lipids through a cold treatment with sulfuric acid concentrate.

2. *limit the microbial growth*, favoured by cutting and handling. To this purpose, active packaging systems have been developed (packages that constantly and actively interact with the internal package atmosphere or directly with the packaged product) containing anti-microbial substances, which are differentiated according to the family of chemical compounds to which they belong (generally antibiotics or ceramic materials), to their biological origin, to the target microorganism or to specific biological functions. These substances can be added to the packaging in various ways: as bags introduced inside

the package; by integrating the substance into the packaging film (using solvent or by extrusion); by means of surface absorption; or using polymers with intrinsic or induced anti-microbial activity.

3. *slow-down ethylene emissions* in order to limit senescence reactions. To this purpose, active packaging systems can be used, which can either remove the ethylene by means of specific substances, as aluminium oxide or potassium permanganate or modified zeolite, or inhibit the action of ethylene exploiting molecules that can bind with ethylene receptors thus counteracting its reactions (silver salts and organic gas molecules belonging to the family of cyclopropenes).

4. *water exchange control*, since most senescence reactions are related to humidity (decay, drying, colour changes, etc.). To this purpose, today humidity absorbers are available, consisting in two layers of polyvinyl alcohol plus a vegetable gel (starch and algal extracts), which scavenge the watery liquids that may be released by fresh produce; another possibility comes from humidity scavengers that remove the water vapour from the environment (sodium or potassium chloride).