These modified atmosphere techniques have the following advantages:

- reduction of weight loss (drying and withering);
- slowing of maturation;
- reduction of the risk of chilling injury;
- conservation of quality (colour, moisture and flavour);
- reduction of distribution losses;

but also some disadvantages:

- the need for extra packaging equipment;
- a risk of problems if the film is poorly identified or if the temperature is not right;
- the possibility of unusual development of anaerobic flora;
- the problem of recycling plastic films.

Our trials are followed by evaluation of the results by control of fruit quality. Physical features (weight loss, firmness and colour) and chemical features (respiration rate, Brix acidity and ethanol content) are controlled. These control measures are particularly important to verify the impact of conservation techniques on fruit quality.

Microperforated films

Tests have been performed with microperforated films with permeability ranged from 10,000 to 150,000 ml/m^2 per 24 hours, with totally impermeable film (OPP) and very permeable film (Cryovac). The aim is to determine the best storage atmosphere for mango to obtain data applicable to selective films. It is observed that the storage of mangoes in strongly impermeable fill is fully able to conserve the outside of the fruit, with the colour being totally preserved. However, this total blockage of maturation is irreversible, whence the usefulness of the dosing of blockage using the appropriate films. It is noted that any permeability of less than 50,000 cannot be used with mango because it result in carbon dioxide accumulation causing fermentation.

Selective films

Trials on selective films must make it possible to incorporate the physiological parameters of the fruit, factors that may modify the latter (temperature, moisture, etc.) and the film parameters (thickness, composition and all the factors likely to modify permeability) to create the ideal atmosphere for lengthening fruit life. The parameters mentioned can be incorporated in a model enabling us to anticipate the results and above all to compare real experiments with modelling. We have worked on three mango varieties (Kent, Keitt and Tommy Atkins) using films of varying permeability (from 5,000 to 20,000 for oxygen and 10,000 to 20,000 for carbon dioxide). The different films used have made it possible to slow changes in fruits both in the external and internal colour and in the overall metabolism of mango. However, the blockage is totally irreversible if the film has not been well chosen. When permeability is well suited to mango (physiology, etc.), maturation can be retarded by 5 to 7 days in the Kent variety (at the sea transport stage) and by 6 to 12 days in the other varieties.

Coatings

We are working on the composition of wax type coatings to adjust the internal gas composition of fruits and which, placed on the surface, slow the metabolism. Different formulations have been developed and their effects on the respiration, biochemical composition and changes during storage have been studied. A shift in the climacteric of fruits has been observed, indicating a slowing of the evolution of coated mangoes but without the total blockage of ripening mechanisms. Such a blockage can be observed when coatings that are too impermeable are used; these halt the evolution of external fruit colouring, with the fruit remaining green for a very long time, and the organoleptic qualities subsequently required are not achieved. The colour can no longer change in this case. The best results are obtained with coatings based on carnauba wax to which polysaccharides are added. The quantity of polysaccharides in the final composition requires further adjustment to optimise these results. These trials have been carried out thanks to our partners in Mali—the CAE and the Fruitex company—who placed fruits at our disposal. Our trials are performed in collaboration with USDA Florida and are to continue during the coming West African season. We plan to conduct trials on other mango varieties from South Africa ■

Optimisation of fruit and vegetable packing under modified atmosphere

Abstract

Complete version
http://technofruits2001.cirad.fr

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The optimisation of the packing of fresh fruits and vegetables under modified atmosphere requires a rigorous approach. It is first necessary to measure the respiratory parameters of the produce (O_2 and CO_2 respiratory intensities, the respiratory quotient, the apparent Michaelis constant for oxygen, the carbon dioxide inhibition constant and the influence of storage temperature on all these parameters). These measurements make it possible to calculate the respiratory intensity of the produce under all conditions of temperature and atmosphere. The second stage is the determination of the most

favourable gas composition for maintaining the commercial and sanitary qualities of the fruits and vegetables concerned. This determination requires storage under controlled atmosphere and the results depend on the weighting of the different deterioration processes. Finally, a mathematical model is used to calculate the optimum permeabilities of the film to be used under the storage conditions entered in the model. Various software is used to simulate storage (the evolution of atmospheres) using the films available on the market and that display permeabilities similar to those previously calculated. At this stage, the functioning of the system can be verified by simulating the thermal profile of a realistic commercial channel.
Finally, it is essential to verify these theoretical results by experimental work as no model is yet capable of forecasting all the types of deterioration possible ■

New coating formulations for the conservation of tropical fruits

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Many storage techniques have been developed over the years to extend the storage life of fruits and vegetables. This helps to expand marketing distances from growing areas. Unfortunately, 25 to 80% of harvested fresh produce are lost due to spoilage each year, with losses being higher in tropical regions. One simple technology to extend the storage life of fruits and vegetables is through the use of edible coatings.

Tropical fruits and vegetables present a special problem in that they are chilling sensitive. Therefore, low temperature cannot be used effectively to extend storage life as, for example, can be done for apples. Often these commodities are shipped long distances to customers in temperate zones by air resulting in higher prices for consumers. Shipment by sea would be desirable, but not currently possible due to the rapid ripening and deterioration of these products

Fruits and vegetables can be classified as climacteric or non-climacteric. Climacteric fruit continue to ripen after harvest, whereas non-climacteric do not. Ripening is a process that includes development of color, flavor and texture (softening). Many important tropical fruits are climacteric, such as banana, mango, papaya, avocado, and guava. These fruit ripen rapidly during transit and storage, thus often requiring rapid shipment by air. There is an opportunity with climacteric fruit, however, to slow down ripening after harvest and, thus, extend the shelf life. This can be done with controlled atmosphere (CA) storage, modified atmosphere packaging (MAP), or with edible coatings. In all cases the atmosphere created is that of relatively low oxygen (O_2) and high carbon dioxide (CO_2) compared to standard atmosphere. The low O_2 and high CO_2 depress ethylene production which is required to turn on ripening genes that effect color changes, aroma and degredation of cell walls that results in softening.

Edible coatings can create a modified atmosphere, similar to that of MAP, which is a function of coating permeability and fruit respiration. In both cases, temperature control is very important since it can affect the rate of fruit respiration. Higher temperatures increase, and lower temperatures decrease fruit respiration rates. Coatings or MAP designed for ideal storage temperatures can cause anerobic respiration, subsequent off-flavor, and fruit deterioration at abusive storage temperatures. Nevertheless, if used properly, edible coatings can delay ripening of climacteric fruit, delay color changes in non-climacteric fruit, reduce water loss, reduce decay, and improve appearance.

Coatings can be formulated from different materials including lipid, resins, polysaccharides, proteins, and synthetic polymers. In fact, most coatings are a composite of more than one film-former with the addition of low molecular weight molecules such as polyols, that serve as plastisizers. These compounds become interspersed among the polymer chains, spreading them apart which imparts more flexibility to the coating. Otherwise, coatings can be too brittle and will flake or crack on the coated product. Surfactants, antifoaming agents, and emulsifiers are also often used in coatings.

Lipid materials used in coatings are generally incorporated as waxes or oils. For waxes: carnauba, candelilla, and rice bran waxes are natural plant waxes; beeswax is also a natural product; and paraffin and polyethylene wax are petroleum-based products. For resins: shellac is a natural product from tree resin, wood rosin is a waste product of the lumber industry, and coumarone indene resin is a petroleum-based product. The latter two resins are only approved for citrus in the U.S., where the peel is not eaten. Lipids are excellent water barriers, but are relatively permeable to gases, and thus, not as useful to create a modified atmosphere to delay ripening. The resins are relatively good water vapor barriers, very shiny, but exhibit relatively low permeability to gases and, thus, can cause anerobic conditions in fruit if there is temperature abuse. Other resins include copal, damar and elimi which are only used in pharmaceuticals.