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Preservation of Fruits and Vegetables at Chilling Temperatures

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Like all living material, fruits and vegetables vary greatly from one species to another, from one cultivar to another. The ability to withstand cold storage varies according to species and cultivars and the choice of these is very important; late varieties are usually best. Differences in the rate of loss of water (thus of shriveling), in incidence of physiological damage (caused by chilling and not microbial), in fungal attack, in the ability to withstand rough handling, etc., are some of those to be considered.

Introduction

Fruits and vegetables are fundamentally different from most other produce, which is cold stored in the fresh (unfrozen) state, in that they are living. They respire; thus suitable ventilation must be provided. During cold storage, they undergo characteristic changes, of senescence, and of ripening of fruits. Like all living material, fruits and vegetables vary greatly from one species to another, from one cultivar to another, and between individual examples of the same cultivar. There has been an attempt to avoid giving too optimistic storage periods, in the tables, since the objective is not just to keep the produce alive, but also to keep it in a satisfactory commercial condition.

The ability to withstand cold storage varies according to species and cultivars and the choice of these is very important; late varieties are usually best. Differences in the rate of loss of water (thus of shriveling), in incidence of physiological damage (caused by chilling and not microbial), in fungal attack, in the ability to withstand rough handling, etc., are some of those to be considered. A second factor, which is important in determining if a given product will tolerate cold storage, is the stage of development at the beginning of storage (use of indicators of degree of maturity of fruits). Finally, notice must be taken of any pre-storage treatments, in the field or orchard, and of steps taken at the time of harvest, packaging, and rapidity of transport to the cold store, etc.

Practical Operations before Cold Storage

1. **Packaging:** Packages (boxes, crates, cartons, etc.) play a protective role against mechanical handling, dust, insectsand infection by fungi, and they can also diminish the rate of loss of water, or hinder gaseous exchange and thus modify the composition of the atmosphere around the produce. Pre-packaging, which is maintained up to the point of consumption has in particular the advantage of maintaining a high relative humidity around the produce, and

thus to preserve their appearance and freshness; weight loss is reduced and the commercial life is increased (carrots, radish, lettuce, etc.). Perforated packages (for apples and pears) allow a certain amount of ventilation, limiting the risk of fermentation and accumulation of carbon dioxide (CO_2) and ethylene.

Washing (e.g. of carrots) may be recommended for some vegetables. The use of fungicides is limited by regulations, which vary widely from one country to another, and this must therefore be taken into account. The risk of sprouting of potatoes or onions may also be reduced by suitable chemical treatments or by irradiation, provided that local regulations permit. Finally, hot water may sometimes have a protective role (e.g. for papaws). A covering of wax has been recommended for some special cases (citrus, turnips, cucumbers, and tomatoes), and fungicides are sometimes incorporated in the wax.

2. **Pre-cooling:** As long as the temperature remains high, transpiration, respiration and the various metabolic processes in the fruits and vegetables will be intense, thus, in general, leading to very rapid changes. Thus it is necessary to cool the produce as rapidly as possible; this reduces loss of water and slows down or inhibits development of micro organisms. Once cooled, the produce must be continuously held at low temperature. The main methods of pre-cooling are: by vacuum, hydro cooling by immersion or spraying with cold water, blast cooling in a current of cold air, or a combination of hydro cooling and blast cooling (hydrair cooling), using a current of air containing a fine mist of water, and finally cooling by contact with ice. Vacuum cooling is mainly used for leaf vegetables such as spinach, lettuce, celery, parsley, etc. Hydro cooling is suitable for melons, peaches, cherries, sweet corn, etc. Blast cooling is used for many products, e.g. strawberries, grapes, cauliflower, etc.
3. **Storage conditions:** This is particularly important if the produce produces much heat, e.g. asparagus, or peas. Storage of different kinds of produce in the same room is possible if they all tolerate the same temperature or if they do not influence each other, either by tainting or accelerating ripening. Fats should never be stored in the same room as fruits, onions, potatoes, etc.The principal parameters of the conditions in the cold store are the temperature of the air, its humidity, the composition of the atmosphere, the speed of movement of the air and the amount of ventilation, as well as the surface temperature of the evaporator.
4. **Storage in air:** The biological activity of the produce depends on its temperature, not on that of the air, measured at a certain point in the room. The initial rate of cooling is important, and should be as rapid as possible.Thus if one needs to keep a wide range of fruits and vegetables in a few chambers, they must be separated into suitable groups, e.g. at 0°C: apples, pears, stone fruits, grapes, berries, green beans, roots; at 7°C: oranges, mandarins, ripe pineapples, coloured tomatoes, potatoes, cucumbers, green beans, papaws, avocados; at 12°C: more sensitive produce such as lemons, grapefruit, bananas, green pineapples, green tomatoes, mangoes, etc. If the desired storage period is short, however, the temperature could well be moderately higher or lower, with no great undesirable effect. Short storage at 5°C to 7°C has the advantage that there is not much surface condensation on return to ordinary temperatures.
5. **Controlled (C.A.) or Modified Atmosphere (M.A.) Storage:** Among the processes, which give a favourable effect, additive to that of low temperature, should be included C.A. storage.

This consists of reduction of the concentration of oxygen and/or increase in the concentration of CO_2 around the produce.

Several types of atmosphere are used, with intermediate variability:

- The sum of the concentrations of CO_2 and O_2 is 21 %, as in air;
- The sum of the two concentrations is below 21 % (e.g. 2, 4);
- The oxygen remains very high, and CO_2 is very low or absent (carrots, oranges);
- CO_2 is added, in high concentration, to air (chestnuts).

Either the concentrations are rigorously controlled and kept as constant as possible (controlled atmosphere, properly speaking), or they may be modified in a less strict fashion to provide a more favourable atmosphere ("modified atmosphere") used in transport. The rooms used must be as gas-tight as possible, with impermeable wall finishes. Regulation of the desired atmosphere needs special equipment (chemical absorption of CO_2, reduction of concentration of oxygen in a catalytic burner, selective diffusion of the gases across a plastic film diffuser, etc.). On the small scale, C.A. storage may be obtained by utilizing the selective permeability to gases of sealed plastic bags.

6. **Ripening of fruits after storage, and their shelf life at ordinary temperatures (Post-storage life):** Pears, plums and peaches do not ripen at 0°C; at the end of the permissible storage life, they will ripen if the temperature is sufficiently increased. The optimum temperature and the duration of the ripening depend on the length of storage at low temperature

Storage Disorders

The most important disorders, apart from shrivel (too dry an atmosphere), freezing (too low a temperature), and tainting by incompatible produce, are microbial development and physiological injury. Microbial damage may be caused by bacteria (carrots, lettuce), but it is more often due to fungi (yeast, and filamentous fungi such as *Penicillium*, *Batrytis*, *Mucor*, etc.). Infection may spread easily from damaged organ to neighbouring organs, due to abundance of spores, especially if conditions are warm and humid, and if the produce is senescent, mechanically damaged, rich in sugar, etc.

Pre-packaging

Pre-packaged fresh produce should only be stored for very short periods and thus, strictly, is outside the terms of these recommendations. At present, it is probably safer not to use plastic containers or bags, which are completely sealed, but to have sufficient perforations in the plastic; otherwise increased losses may appear from mould attack, due to high humidity in the package, if fungicidal treatment has not been applied, or from too high concentrations of carbon dioxide and other products of metabolism. The use of box liners, for instance, for apples and pears may be useful.

Conclusion

After produce is harvested, growers must follow proper management techniques and procedures given in this document to offer a fresh and good-looking product to the wholesaler, retailer and consumer, and to get the maximum return on their investment. Proper management and handling practices require a reduction in produce temperature to maintain quality and market value.