Advances in CA/MA Applications

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As supplements to keeping fresh horticultural perishables within their optimum ranges of temperature and relative humidity, controlled atmospheres (CA) or modified atmospheres (MA) during postharvest handling can extend their postharvest-life. Optimum ranges of oxygen and carbon dioxide concentrations lower respiration and ethylene production rates, reduce ethylene action, delay ripening and senescence, retard growth of decay-causing pathogens, and control insects. On the other hand, CA conditions unfavorable to a given commodity can induce physiological disorders and enhance susceptibility to decay.

Several refinements in CA storage technology have been made in recent years, including creating nitrogen on demand by separation from compressed air using molecular sieve beds or membrane systems, use of lower oxygen concentrations (0.7 to 1.5%) that can be accurately monitored and controlled, rapid establishment of CA, ethylene-free CA, programmed (or sequential) CA (such as storage in 1% O_2 for 2 to 6 weeks followed by storage in 2-3% O_2 for remainder of the storage period), and dynamic CA where levels of O_2 and CO_2 are changed as needed based on monitoring some attributes of produce quality.

There are continued improvements in attaining and maintaining CA in refrigerated marine containers. CA transport is used to continue the CA chain for some commodities (such as apples, pears, and kiwifruits) that had been stored in CA since harvest. CA transport of bananas permits their harvest when more fully-mature (higher yield). CA transport of avocados facilitates use of a lower temperature [5°C (41°F)]. CA combined with precision temperature management allow nonchemical insect control in some commodities for markets that have restrictions against pests endemic to exporting countries and for markets that prefer organic produce.

There is a continuing increase in the number of companies that make polymeric films for packaging produce and in the use of modified atmosphere packaging (MAP) systems at the pallet, shipping container (plastic liner), and consumer package levels. The greatest use of MAP (usually to maintain 2 to 5% O_2 and 8 to 12% CO_2) is on fresh-cut vegetable and fruit products. Use of absorbers of ethylene, carbon dioxide, oxygen, and/or water vapor as part of MAP is increasing. Although much research has been done on use of surface coatings to modify the internal atmosphere within the commodity, commercial applications are still very limited due to the inherent biological variability of the commodity.

Commercial use of CA during storage and transport is greatest on apples and pears, less on kiwifruits, avocados, persimmons, pomegranates, and nuts and dried products. Atmospheric modification during long-distance transport is used on apples, avocados, bananas, blueberries, cherries, figs, kiwifruits, mangoes, nectarines, peaches, pears, plums, raspberries and strawberries. Continued technological developments in the future to provide CA during transport and storage at reasonable cost (positive benefit/cost ratio) are essential to expanded application on fresh fruits and vegetables, especially those listed in Table 1.

Table 1. Classification of fruits and vegetables according to their CA storage potential at optimum temperatures and relative humidities.

Range of storage duration (months)	Commodities
More than 12	Almond, Brazil nut, cashew, filbert, macadamia, pecan, pistachio, walnut, dried fruits and vegetables.
6 - 12	Some cultivars of apples and European pears.
3 - 6	Cabbage, Chinese cabbage, kiwifruit, persimmon, pomegranate, some cultivars of Asian pears.
1 - 3	Avocado, banana, cherry, grape (no SO_2), mango, olive, onion (sweet cultivars), some cultivars of nectarine, peach and plum, tomato (mature-green).
<1	Asparagus, broccoli, cane berries, fig, lettuce, muskmelons, papaya, pineapple, strawberry, sweet corn, fresh-cut fruits and vegetables.

Future R&D needs include the following areas:

1. Continuing studies to better understand the biological bases of oxygen and carbon dioxide effects on postharvest quality of fruits, vegetables, and flowers.
2. Continuing investigations of the physiological and biochemical basis of CA-induced physiological disorders; reasons for genotypic differences in tolerance of a given commodity to reduced O_2 and/or elevated CO_2 concentrations.
3. Elucidating the mode of action of elevated O_2, elevated CO_2, ethylene, and carbon monoxide on postharvest pathogens and insects.
4. Continued development of optimum modified atmosphere packaging technologies for various commodities including evaluation of various types of O_2, CO_2, C_2H_4, and water vapor absorbers for their effectiveness in helping maintain the desired microenvironment within modified atmosphere packages.
5. Developing dynamic controlled atmosphere procedures for use during transport and storage of horticultural perishables.
6. Investigating the potential of using superatmospheric O_2 levels plus 15-20% CO_2 for decay control without detrimental effects on fruit quality.