Future of Modified Atmosphere Research

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Abstract

It is not possible to discuss the future of modified atmosphere (MA) research without considering the broader aspects of research aimed at maintaining quality of fresh horticultural perishables between harvest and consumption. Providing better flavored fruits and vegetables is likely to increase their consumption, which would be good for the producers and marketers (making more money or at least staying in business) as well as for the consumers (increased consumption of healthy foods). To achieve this goal, we and all those involved in producing and marketing fruits and vegetables need to: (1) replace poor flavor cultivars with good flavor cultivars from among those that already exist and/or by selecting new cultivars with superior flavor and good texture; (2) identify optimal cultural practices that maximize flavor quality, such as optimizing crop load and avoiding excess nitrogen and water; (3) encourage producers to harvest fruits at partially-ripe to fully-ripe stages and vegetables at their optimal maturity stages by developing handling methods that protect these commodities from physical damage; (4) identify optimal postharvest handling conditions (time, temperature, relative humidity, atmospheric composition) that maintain flavor quality of fruits and vegetables and their value-added products. Postharvest-life should be determined on the basis of flavor rather than appearance. The end of flavor-life results from losses in sugars, acids and aroma volatiles (especially esters) and/or development of off-flavors (due to fermentative metabolism or odor transfer from fungi or other sources); (5) develop ready-to-eat, value-added products with good flavor; and (6) optimize maturity/ ripeness stage at the time of processing and select processing methods to retain good flavor of the processed products. Future modified atmosphere research can be part of research on strategies number 4, 5 and 6 listed above. Continued improvements in polymeric films and other packaging materials will facilitate expanded use of MA packaging to extend postharvest-life of fresh-cut fruits and vegetables and permit their distribution via vending machines. More cost-effective methods for establishing and maintaining MAs will facilitate their use during storage at shipping points, transportation and storage at destination points. Maintaining the MA chain is the second most important factor after the cold chain in keeping quality and safety of fresh produce between harvest and consumption. Further evaluations are needed of: (1) the synergistic effects of MA and the ethylene-action-inhibitor,1-methylcyclopropene, on delaying ripening of partially-ripe climacteric fruits and senescence of vegetables ; (2) MA as a component of postharvest integrated pest management (decay and insect control); (3) MA in relation to food safety considerations; and (4) the biological bases of MA effects on fresh horticultural perishables.

TRENDS IN MARKETING FRESH PRODUCE

Current trends that are expected to continue in the future include globalization of produce marketing, consolidation or formation of alliances among producers and marketers from various production areas, consolidation of retail marketing organizations and increased demand for year round supply of many produce items with better flavor. Maintaining the cold chain and the modified atmosphere chain when needed are very

important to globalization of produce marketing. For some commodities (such as apples, pears and kiwifruits), a year round supply from northern and southern hemisphere countries eliminates price incentives to domestic producers for "out-of-season" produce. This reduces the need for CA storage beyond 6 or 7 months in either hemisphere and has the potential of providing the consumers with better flavor-quality fruits. Also, there will be opportunities for using available CA storage facilities to store fruits from the other hemisphere (that are transported under optimal CA conditions) after the end of storage of locally produced fruits.

FLAVOR QUALITY OF FRUITS AND VEGETABLES

It is not possible to discuss the future of modified atmosphere (MA) research without considering the broader aspects of research aimed at maintaining quality of fresh horticultural perishables between harvest and consumption. Flavor attributes and associated constituents include sweetness (sugars), sourness or acidity (acids), astringency (tannins), bitterness (isocoumarins), aroma (odor-active volatile compounds), off-flavors (acetaldehyde, ethanol, and/or ethyl acetate above certain concentrations) and off-odors (sulfurous compounds above certain concentrations). Nutritional quality of fruits and vegetables is determined by their contents of vitamins, minerals, dietary fiber and antioxidant phytochemicals, such as carotenoids and flavonoids. It is important to determine the effects of modified atmospheres during postharvest handling on these constituents as indicators of flavor and nutritional quality of intact and fresh-cut fruits and vegetables.

Providing better flavored fruits and vegetables is likely to increase their consumption, which would be good for the producers and marketers (making more money or at least staying in business) as well as for the consumers (increased consumption of healthy foods). To achieve this goal, we and all those involved in producing and marketing fruits and vegetables need to do the following:

1. Replace poor flavor cultivars with good flavor cultivars from among those that already exist and/or by selecting new cultivars with superior flavor and good textural quality.
2. Identify optimal cultural practices that maximize flavor quality, such as optimizing crop load and avoiding excess nitrogen and water, which along with low calcium shorten the postharvest-life of the fruits and vegetables due to increased susceptibility to physical damage, physiological disorders and decay.
3. Encourage producers to harvest fruits at partially-ripe to fully-ripe stages and harvest vegetables at their optimal maturity stages by developing handling methods that protect these commodities from physical damage.
4. Identify optimal postharvest handling conditions (time, temperature, relative humidity, atmospheric composition) that maintain flavor quality of fruits and vegetables and their value-added products. Postharvest-life should be determined on the basis of flavor rather than appearance. Most of the published estimates of postharvest-life under modified or controlled atmospheres are based on appearance (visual) quality, and in some cases, textural quality. These estimates should be revised to reflect the end of flavor-life when the product looks good but does not taste good. The end of flavor-life results from losses in sugars, acids and aroma volatiles (especially esters) and/or development of off-flavors (due to fermentative metabolism or odor transfer from fungi or other sources). The possible role of modified atmospheres in delaying these undesirable changes should be investigated.
5. Develop ready-to-eat, value-added products with good flavor. A very important research area is to find the optimal atmospheres for delaying browning and softening of fresh-cut products during distribution within the optimal ranges of temperature and relative humidity.
6. Optimize maturity/ ripeness stage at the time of processing and select processing methods to retain good flavor of the processed products.

Future modified atmosphere research can be part of research on strategies number 4, 5 and 6 listed above.

MAINTAINING THE MA CHAIN

Continued improvements in polymeric films and other packaging materials will facilitate expanded use of MA packaging to extend postharvest-life of fresh-cut fruits and vegetables and permit their distribution via vending machines and quick-service restaurants. MAP is an effective way to maintain the desired atmospheric composition between shipping point and the consumer's home. When evaluating polymeric films, it is important to place the control product in perforated plastic bags to separate the effect of the film on reducing water loss from its effect as a barrier to carbon dioxide and oxygen diffusion. Instead of developing more models for MAP, researchers are encouraged to build upon existing models and improve their accuracy.

Although much research has been done on the use of surface coatings to modify the atmosphere within many commodities, this technology has not been used to any extent because of the variability in composition among batches of the coating material. When combined with the natural variation in the gas diffusion characteristics among individual commodity units, a portion of each lot is lost due to off-flavors caused by fermentative metabolites. Further research is needed to overcome these constraints to use of surface coatings for modification of internal atmospheres of fruits and vegetables.

More cost-effective methods for establishing and maintaining MAs will facilitate their use during storage at shipping points, transportation and storage at destination points. Maintaining the MA chain is the second most important factor after the cold chain in keeping quality and safety of fresh produce between harvest and consumption.

COMBINED EFFECTS OF MA AND 1-MCP

Further evaluations are needed of the synergistic effects of MA and the ethylene-action-inhibitor, 1-methylcyclopropene, on delaying ripening of partially-ripe climacteric fruits and senescence of vegetables and deterioration (browning and softening) of fresh-cut products.

MA FOR DECAY AND INSECT CONTROL

More research is needed to evaluate the efficacy of MA as a component of postharvest integrated pest management (decay and insect control) in fresh horticultural perishables. The fungistatic and insecticidal effects of low oxygen, elevated carbon dioxide and superatmospheric oxygen MA alone or in combination with other treatments merit further investigation.

MA AND FOOD SAFETY CONSIDERATIONS

More research is needed to quantify the effects of MA on growth of pathogenic bacteria on fresh produce and on production of mycotoxins by fungi. Also, we need to understand how do high oxygen concentrations alone or in combination with elevated carbon dioxide concentrations influence growth of decay-causing bacteria and fungi and of human pathogens?

BIOLOGICAL BASES OF MA EFFECTS

Studies of the biological bases of MA effects on fresh horticultural perishables should be expanded to include superatmospheric oxygen concentrations and their interactions with elevated carbon dioxide levels.

RETURN ON INVESTMENT OF MA

Future expansion in the commercial use of MAP, MA during transport and CA storage will depend on demonstrating a positive return on investment (ROI). Thus, it is important to estimate the ROI of every application before recommending its use.

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