Summary of CA for Arthropod Control on Fresh Horticultural Perishables

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Abstract

The literature on controlled atmospheres (CA) for arthropod control on fresh horticultural perishables is summarized. Four basic approaches to control of arthropod pests are discussed, including regular CA storage, low temperature insecticidal CA, room temperature insecticidal CA, and high temperature insecticidal CA. Insecticidal CA (ICA) generally involves O_2 concentrations below 2 kPa and/or CO_2 concentrations of 20 kPa or greater. In recent years, researchers have focused more on high temperature ICA with reduced activity in the other three areas. In addition, there has been less research on the tolerance of fresh commodities to ICA in recent years. To date, CA has not been approved as an official quarantine method, although it is used during storage of dried fruits and nuts for insect control.

INTRODUCTION

Controlled atmosphere treatments are an attractive alternative for postharvest insect control. In addition to CA's potential as an alternative to methyl bromide, a popular fumigant used for insect control and whose use will be restricted in 2003, CA provides a non-chemical treatment that leaves no residues in the commodity. For some commodities, such as the dried fruits and nuts, exposure to insecticidal CA (ICA) can be beneficial in maintaining product quality as well as controlling insect pests. Controlled atmosphere treatments can potentially be accomplished in marine containers during the voyage to distant export markets. This treatment avenue is important for timely marketing, as many of the CA treatments require several days to weeks for efficacy against target pests.

CATEGORIES OF CA RESEARCH ON ARTHROPOD CONTROL

There are four basic categories of research on the use of CA for insect control, 1) regular CA, 2) low temperature ICA, 3) room temperature ICA and 4) high temperature ICA. Prior to 1997, when the last CA conference was held in Davis, Calif., most of the research on arthropods focused on room temperature CA treatments, and numerous studies on the tolerance of perishable commodities to ICA were conducted (Table 1). Since 1997, the focus has shifted to high temperature CA treatments, with less emphasis on specific testing for product tolerance.

Regular or Moderate CA

Much of the initial effort in development of ICA involved testing of atmospheres and cold temperatures commonly used for storage life extension. Atmospheres included 1.2 to 3 kPa O_2 and 1 to 3 kPa CO_2 at temperatures of 0.5 to 2 °C (Table 1). The durations tested were in months (0.75 to 8 months) and much of the research was for apple fruit, but also included apricot and asparagus. Arthropods tested included aphids, various leafrollers, New Zealand wheat bug, and San Jose scale. The effort in this research area has decreased since 1992, likely due to the very long treatment times required for efficacy.

Low Temperature Insecticidal CA

Research on low temperature ICA involved 0 to 11.5 kPa O_2 and 18-90 kPa CO_2 at 0 to 5°C. Durations of effective treatments ranged from 1 to 24 days (Table 1). Research in this area has been slow but steady for many years. The research generally involved commodities intolerant to warm temperatures such as leafy vegetables, broccoli, strawberries, grapes and cut flowers. Arthropods tested included aphids, apple maggot, flour beetle, leafrollers, mites and thrips.

Room Temperature Insecticidal CA

The greatest amount of research has involved exposure to ICA at room temperature (10 to 28°C). Research in this area has been steady for a number of years, but may be trending down, perhaps as a result of the increase in research on high temperature ICA (Table 1). Atmospheres ranged from 0 to 12 kPa O_2 and 0 to 100 kPa CO_2. Durations of treatment required for arthropod control were still in days, but somewhat shorter than for low temperature ICA (0.75 to 15 d). Treatments have been developed for a wide range of commodities (apple, citrus, cut flowers, dried fruit, grape, leafy vegetables, mango, persimmon, sweet potato, walnut) and arthropods (aphids, apple maggot, fruit flies, leafrollers, longtailed mealybug, moths, nitidulid beetle, New Zealand wheat bug, San Jose scale, sweet potato weevil).

High Temperature Insecticidal CA

Research into high temperature (28 to 55°C) ICA has been increasing since 1990 (Table 1). Atmospheres have ranged from 0 to 4 kPa O_2 and 0 to 60 kPa CO_2, and effective treatment times are in hours (1.2 to 15 h) as compared with days or months at cooler temperatures. High temperature ICA provides a double stress on the arthropod and commodity resulting in much more rapid mortality. The atmospheres tested were similar to ICA tested at lower temperatures. Studies have shown that the inclusion of ICA with a forced hot air treatment reduces the time to insect mortality by 50% or more (Neven and Mitcham, 1996). However, the addition of the ICA can increase phytotoxicity as compared to hot air alone. Research in this area has involved fruit flies, leafrollers, moths, tuber mealybug, New Zealand wheat bug, sweet potato weevil and thrips on apple, cherry, grapefruit, kiwifruit, mango and sweet potato.

COMMODITY TOLERANCE TO INSECTICIDAL CA

There is a large volume of data on the tolerance of fresh horticultural perishables to ICA. Some studies involved specifically testing the commodity tolerance to ICA, while other studies focused on arthropod control with a casual observance of commodity tolerance. In some cases, the researchers were exploring the use of CA for other purposes, such as decay control. A comparison of the four-year periods 1992 to 1996 and 1997 to 2001 indicates that research on commodity tolerance to ICA has decreased significantly, and there are now similar numbers of manuscripts dealing with commodity tolerance (16) and arthropod control (19).

REASONS FOR LOW COMMERCIAL ADOPTION

The reasons for low commercial adoption of ICA treatments, particularly for quarantine and preshipment uses are several. The continued availability of inexpensive fumigants has likely contributed; however, this situation will likely change within a few years as the availability of methyl bromide decreases and the price increases with the ban on all uses other than quarantine in developed countries in 2003.

Fumigants, such as methyl bromide, are very broad spectrum and can control a large number of arthropod species that may be hitchhiking on the commodity in addition to the specific target pests. The variability in response of arthropods and lifestages within a species to ICA treatment does not allow the same degree of broad spectrum arthropod control. In developing a quarantine treatment for table grapes to Australia, three out of four target pests were successfully controlled with ICA treatment. A different treatment

approach appears to be necessary to achieve full control of all four target pests.

Finally, the ability to maintain ICA in marine containers has been a limitation to application of these treatments during transportation to distant export markets. The ability to seal the container to achieve 0_2 concentrations of ≤ 1 kPa has been an issue. In addition, the availability of a supply of CO_2 for maintaining very high concentrations during transit (≥ 20 kPa) has also been an issue. Collaborations with shipping companies in the development of the required technology are needed.

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Tables

Table 1. General types of CA treatments under study for control of arthropod pests on fresh horticultural perishables and the numbers of publications in each area.

	Temp. °C	O_2 kPa	CO_2 kPa	Duration	Prior to 1992[z]	1992 to 1996[y]	Since 1997[x]
Regular CA	0.5-2	1.2-3	1-3	0.75-8.0 m	7	0	3
Low Temp. CA	0-5	0-11.5	18-90	1-24 d	3	4	2
Room Temp. CA	10-28	0-12	0-100	0.75-15 d	6	6	4
High Temp. CA	28-55	0-4	0-60	1.2-15 h	1	6	10
Commodity Tolerance	0-48[w]	0-21	0-100	25 min – 4.5 m	33	29	16

[z]Research results published in 1991 or earlier.
[y]Research results published between 1992 and 1996
[x]Research results published in 1997 or later.
[w]Commodity tolerance has been studied in all areas.